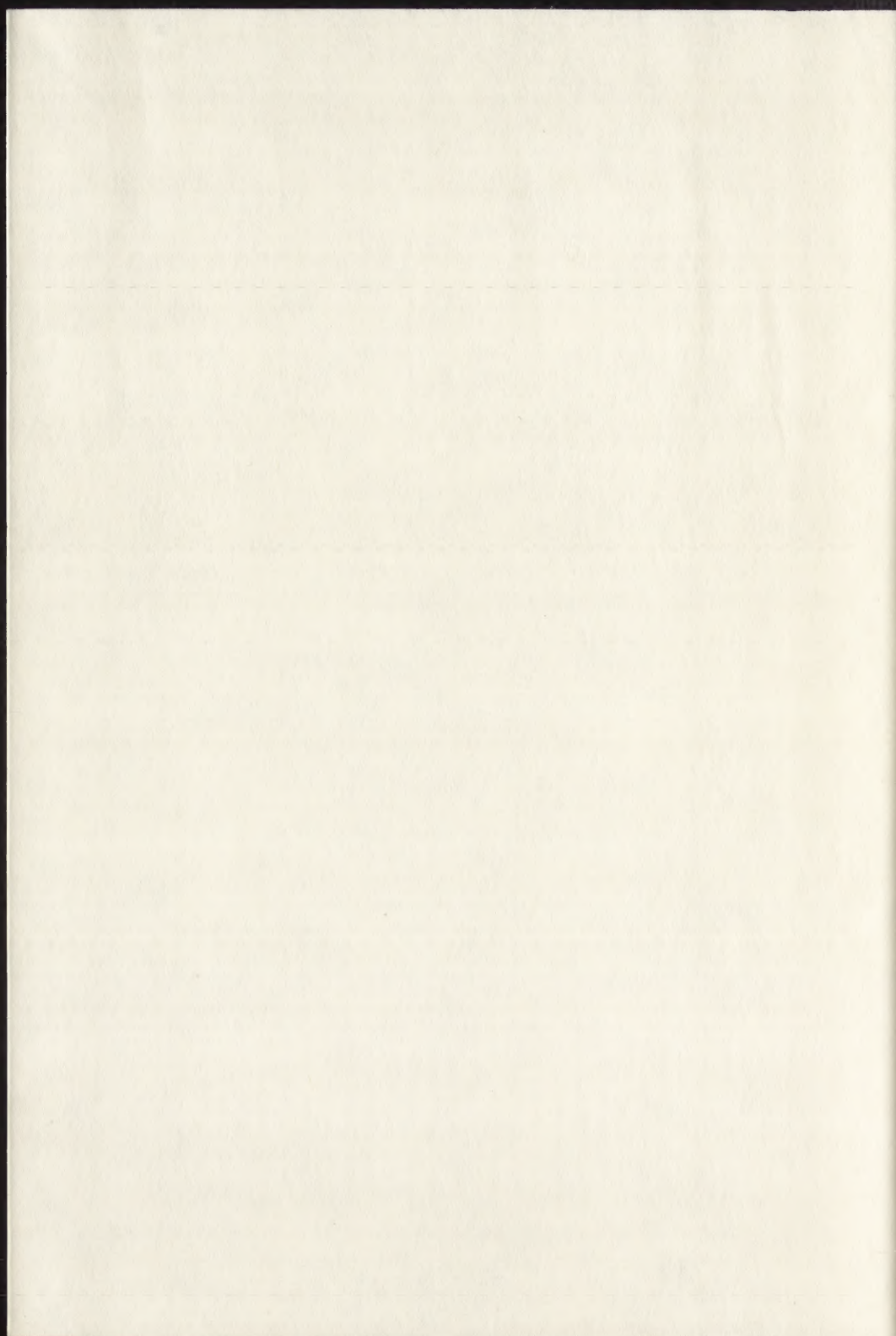


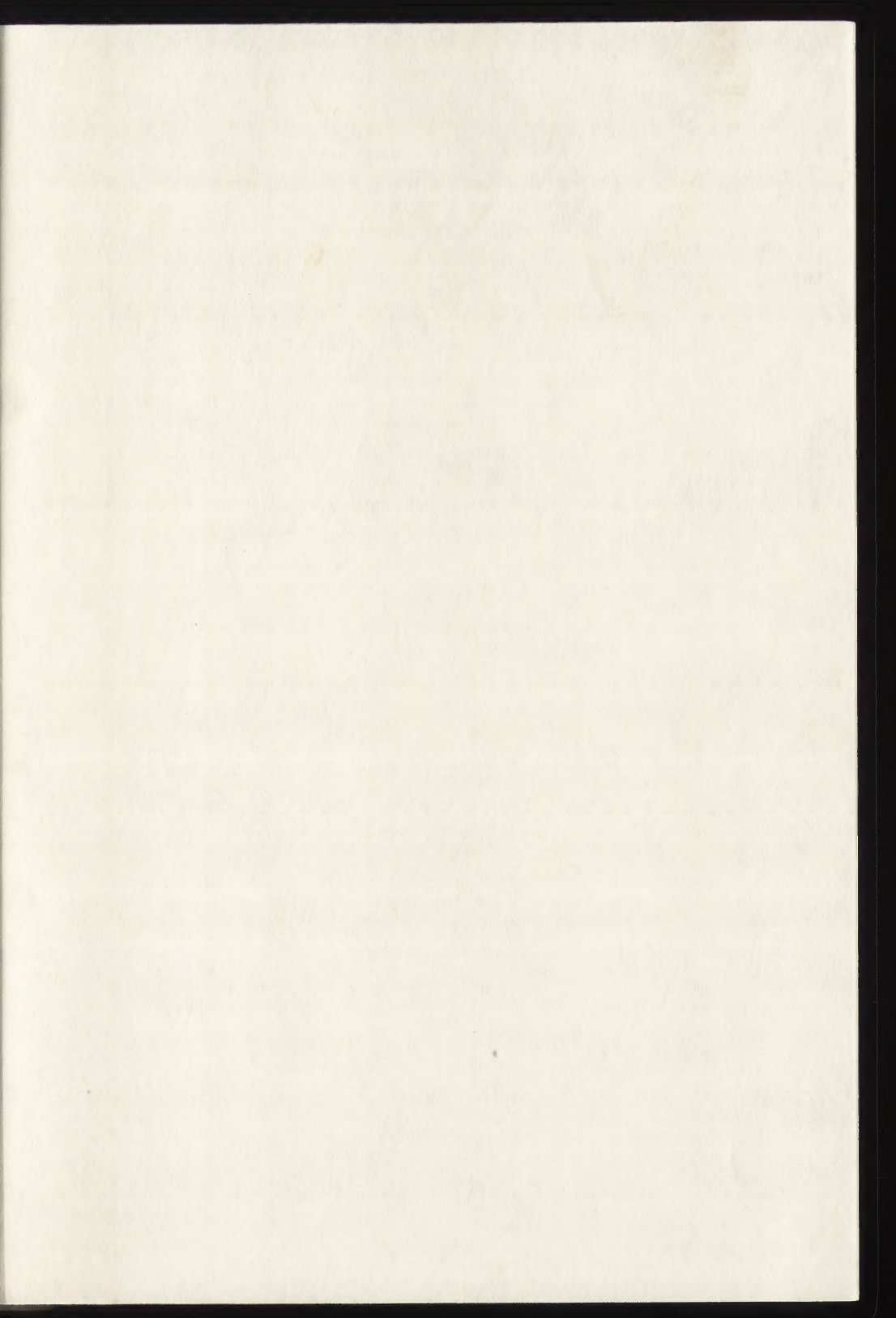
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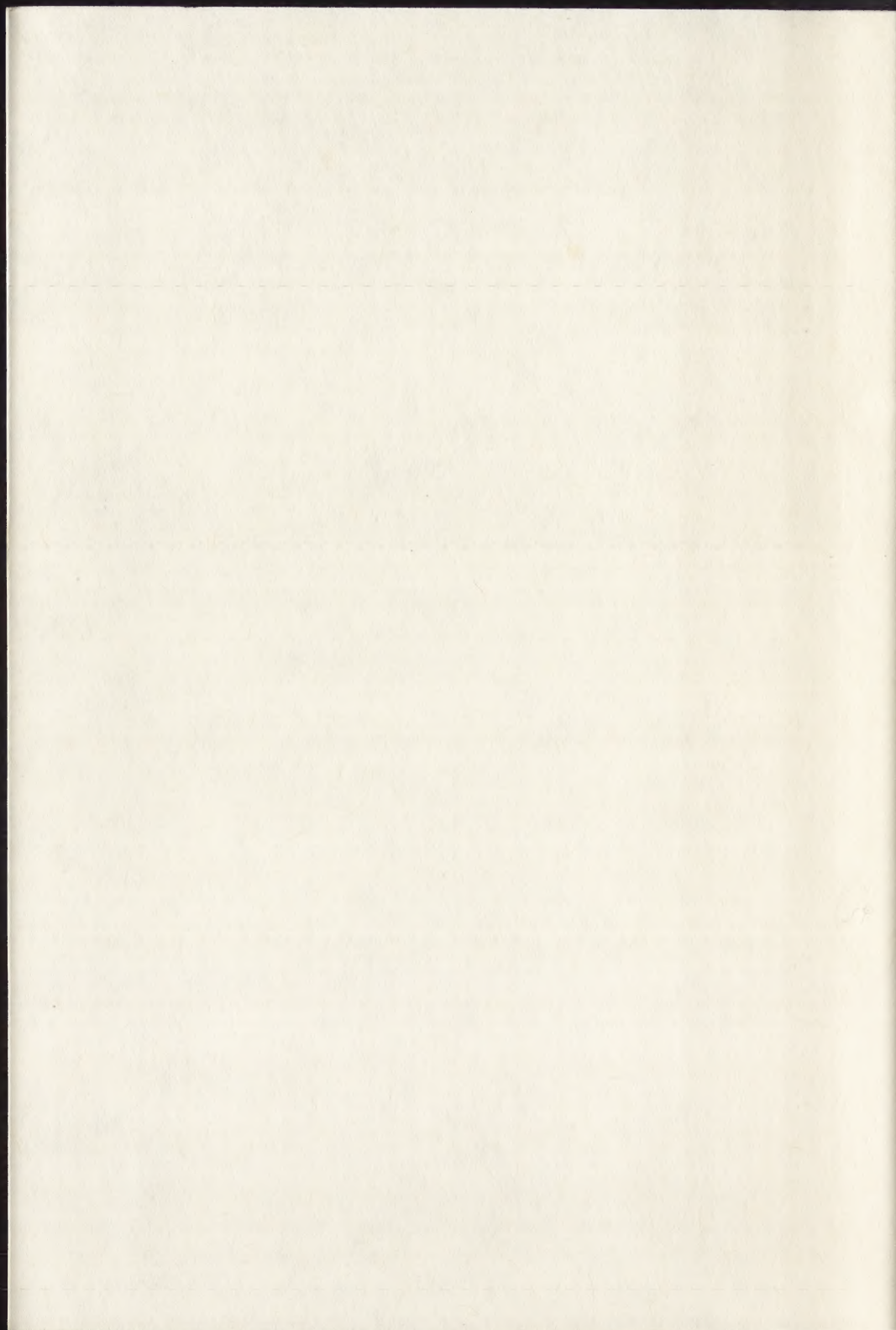


*Why ask for the moon
when we have the stars?*









ICOM COMMITTEE FOR CONSERVATION
6th Triennial Meeting
Ottawa, 21-25 September 1981

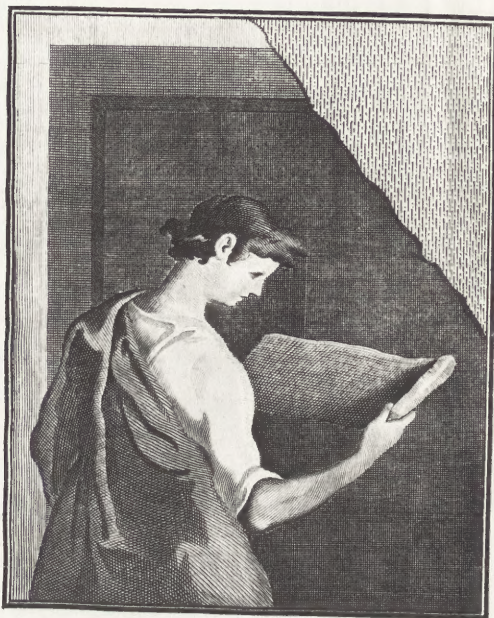
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ICOM COMMITTEE

6th Triennial

Ottawa, 2



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ICOM Committee for ConservationComité pour la conservation de l'ICOMDirectory Board 1978-1981Conseil de direction 1978-1981

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Participants in the meetings of the ICOM Committee for Conservation are personally invited not as representatives of their country or Institution but as specialists in their field.

Les participants aux réunions du Comité pour la conservation de l'ICOM sont invités personnellement à titre de spécialiste; ils ne représentent ni leur pays ni leur institution.

Working Group and Coordinator 1978-1981Groupe de travail et Coordinateur 1978-1981

1. New Applications of Methods of Examination/
Nouvelles applications de méthodes d'examen
 - Ch. Lahanier, Coordinator
Laboratoire de Recherche des Musées de France
Palais du Louvre (Pavillon Flore)
Paris 1, France
 - H.C. von Imhoff, Assistant coordinator
Le Bugnon 308
1782 Belfaux, Switzerland/Suisse
2. Structural Restoration of Canvas Paintings/
Restauration structurale des peintures sur toile
 - W.W. Percival-Prescott, Coordinator
National Maritime Museum Greenwich
London SE 10 9NF, U.K./Royaume Uni
 - P. Boissonnas, Assistant coordinator
Baschligplatz 1
8032 Zürich, Switzerland/Suisse
3. Ethnographic Materials/ Matériaux ethnographiques
 - W.P. Bauer, Coordinator
Museum für Völkerkunde
Neue Hofburg
1014 Vienna, Austria/Autriche
 - E. Schaffer, Assistant coordinator
904-71 Somerset St. West
Ottawa, Ontario K2P 2G2, Canada
4. Documentation/ Documentation
 - Y. Grenberg, Coordinator
Ministry of Culture SSSR
WCNILKR
10 Khrestyanskaya pl.
Moscow, USSR/URSS
 - F.S. Bergeon, Assistant coordinator
Service de Restauration des Peintures des Musées
Nationaux
Musée du Louvre
Palais du Louvre
Paris 75001, France

5. Polychromed Sculpture/ Sculpture polychrome

- P. Philippot, Coordinator
178 Avenue Chr. Michiels
Boîte 17
Brussels 1170, Belgium/Belgique
- A. Ballestrem, Assistant coordinator
Landeskonservator Rheinland
Bachstrasse 9
53 Bonn, Fed. Rep. of Germany/Rép. Féd. d'Allemagne

6. 20th Century Paintings/ Peintures du 20ème siècle

- P. Cadorin, Coordinator
Kunstmuseum
St. Albangraben 16
CH-4051 Basel, Switzerland/ Suisse
- D. Giraudy, Assistant coordinator
Centre National d'Art et de Culture
Centre G. Pompidou
78 Rue Beaubourg
Paris, 75003, France

7. Waterlogged Wood/ Bois gorgés d'eau

- C. Pearson, Coordinator
C.C.A.E.
P.O.Box 1
Belconnen ACT 2616, Australia/Australie

8. Référence Materials/ Matériaux de référence

- J. Winter, Coordinator
Freer Gallery of Art
Smithsonian Institution
Washington D.C., 20560, USA/Etats-Unis
- J. Mosk, Assistant coordinator
Centraal Laboratorium voor Onderzoek van Voorwerpen
van Kunst en Wetenschap
Gabriël Metsustraat 16
1071 EB Amsterdam, The Netherlands/Pays-Bas

9. Textiles/ Textiles

- J.H.Hofenk-de Graaff, Coordinator
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- M. Flury-Lemberg, Assistant coordinator
Abegg-Stiftung Bern
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10. Stone/ Matériaux pierreux
 - J. Lehmann, Coordinator
Muzeum Narodowe
Al. Marcinkowskiego 9
61-745 Poznan, Poland/Pologne
 - J. Riederer, Assistant coordinator
Staatliche Museen Preussischer Kulturbesitz
Rathgen-Forschungslabor
D 1000 Berlin 30, Germany Dem. Rep./Rép. Dém. de l'All.
11. History and Theory of Restoration/
Théorie et histoire de la restauration
 - H. Althöfer, Coordinator
Restaurierungszentrum der Landeshauptstadt Düsseldorf
Ehrenhof 5
4 Düsseldorf-N., Fed. Rep. of Germany/ Rép. Féd. de l'All.
 - I.P.Gorine, Assistant coordinator
WCNILKR
10 Khrestyanskaya pl.
Moscow, USSR/URSS
12. Care of Works of Art in Transit/
Protection des oeuvres d'art pendant le transport
 - N. Stolow, Coordinator
Special Adviser (Conservation)
National Museums of Canada
L'Esplanade Laurier 22nd Floor
Ottawa K1A 0M8, Canada
 - A. Rojas-Garcia, Assistant coordinator
Mirazul 83
Cuautitlan Izcalli
Estado de Mexico, Mexico/Mexique
13. Natural History Collections/ Collections d'histoire naturelle
 - G. Meurgues, Coordinator
Muséum National d'Histoire Naturelle
Service National de Muséologie
Laboratoire de Naturalisation
36 Rue Geoffroy-Saint-Hilaire
Paris 5, France
14. Graphic and Photographic Documents/
Documents graphiques et photographiques
 - F. Flieder, Coordinator
Centre de Recherches sur la Conservation des
Documents Graphiques
Muséum National d'Histoire Naturelle
36 Rue Geoffroy-Saint-Hilaire
Paris 5, France

15. Mural Paintings and Mosaics/
Peintures murales et mosaïques
 - P. Mora, Coordinator
Istituto Centrale del Restauro
9 Piazza S. Francesco di Paola
Roma 00184, Italy/Italie
 - L. Sbordoni Mora, Assistant coordinator
Via Appia Antico 228
Roma, Italy/Italie
16. Protective Coatings, Traditional and Modern/
Couches protectrices, traditionnelles et modernes
 - R.L.Feller, Coordinator
Carnegie Mellon Institute
4400 Fifth Avenue
Pittsburgh, Penn. 15213, USA/Etats-Unis
 - E. de Witte, Assistant coordinator
Institut Royal du Patrimoine Artistique
1 Parc du Cinquantenaire
1040 Brussels, Belgium/Belgique
17. Nuclear Applications to Conservation/
Applications nucléaires à la conservation
 - Chr. de Tassigny, Coordinator
Centre d'Etudes Nucléaires de Grenoble
Département des Radioéléments
Cedex no. 85
38 Grenoble Gare, France
 - R. Ramière, Assistant coordinator
CENG Sarr
B.P. no. 85, Centre de Tri
38041 Grenoble Cedex, France
18. Control of Climate and Lighting/
Contrôle du climat et de l'éclairage
 - G. de Guichen, Coordinator
International Centre for Conservation
13 Via di S. Michele
Roma, Italy/Italie
19. Conservation of Leathercraft and Related Objects/
Conservation des cuirs artisanaux et objets similaires
 - T. Stambolov, Coordinator
Centraal Laboratorium voor Onderzoek van Voorwerpen
van Kunst en Wetenschap
Gabriël Metsustraat 8
1071 EA Amsterdam, The Netherlands/Pays-Bas

20. Easel Paintings/ Peintures de chevalet

- H. Kühn, Coordinator
Deutsches Museum
8 München 26, Fed. Rep. of Germany/ Rép. Féd. de l'All.
- S. Delbourgo, Assistant coordinator
Laboratoire de Recherche des Musées de France
Palais du Louvre
75001 Paris, France

21. Silicious Archaeological Materials/
Matériaux siliceux archéologiques

- L. Vlad Borrelli, Coordinator
Via XXIV Maggio 51
Roma, Italy/Italie
- E. Porta, Assistant coordinator
Museo Arqueologico de Barcelona
Fundacion General Mediterranea
Parque de Montjuic
Barcelona 4, Spain/Espagne

22. Training of Restorers/ Formation des restaurateurs

- H.C. von Imhoff, Coordinator
Le Bugnon 308
1782 Belfaux, Switzerland/Suisse
- A. Ballestrem, Assistant coordinator
Landeskonservator Rheinland
Bachstrasse 9
53 Bonn, Fed. Rep. of Germany/Rép. Féd. de l'Allemagne

23. Metals/Métaux

- R.M.Organ, Coordinator
Conservation-Analytical Laboratory
Smithsonian Institution
Washington D.C., 20560, USA/Etats-Unis

24. Icons/Icônes

- I.P.Gorine, Coordinator
WCNILKR
10 Khrestyanskaya pl
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Composition and working rules for the ICOM Committee for Conservation

1. The Committee and its aims

1.1 *The ICOM Committee for Conservation* is a permanent committee of the International Council of Museums.

Among its aims are :

- a. The achievement and maintenance of the highest standards of conservation and examination of historic works by bringing together from all countries those who are responsible for cultural property: restorers, research workers and curators.
- b. to promote researches of a scientific or technological nature pertaining thereto.
- c. to collect data and information about materials and workshop methods.
- d. to make generally available by publication or otherwise the results of such enquiries.

1.2 *The ICOM Committee for Conservation* is composed of the *Directory Board* and *Working Groups* with their *Coordinators*.

The members of the Directory Board and the Coordinators must be members of ICOM or must undertake to become members within three months of appointment; membership is not considered to be an essential requirement in other cases.

2. Directory Board

2.1 The Directory Board (hereinafter called the Board) is composed of eight members elected for three years by the Committee and one ex-officio member, namely the Director of the Rome Centre. Members are eligible for reelection.

2.2 The board elects its Chairman from among the elected members and appoints an Administrative Secretary and a Secretary for Publications.

2.3 Among the elected members of the Board, who may also be Coordinators, should be represented Museum Curators, Restorers and Museum Scientists.

2.4 Delegates from international organizations such as UNESCO, IIC, and ICOMOS will normally be invited to attend meetings of the Board as observers.

2.5 The Board will endeavour to meet at least once every year.

2.6 The functions of the Board are the following :

- a. to appoint Coordinators for definite tasks and for fixed periods of time.

b. to establish with Coordinators the programme of the Committee for Conservation.

c. to control the progress of work.

3. Coordinators

3.1 Coordinators will hold their offices at the discretion of the Board.

3.2 The Coordinator will choose the members of his Working Group in consultation with and with the approval of the Board and will direct its activities.

3.3 With the approval of the Board the Coordinator may organize joint meetings of specialists in his field, visits to laboratories, sites, etc., having a direct bearing on the progress of his investigation.

3.4 Each Coordinator will submit, annually, to the Secretariat of the Committee for Conservation and not later than 3 weeks before the meeting of the Board, a report on the progress of the work of his group.

4. Working Group Members

4.1 On a proposal from the Coordinator, and with the approval of the Board, members will be assimilated in a group and be allocated a particular subject to study.

5. Procedure and Finance

5.1 The Committee for Conservation meets normally every 3 years in full session to hear reports on the progress of the work being carried out by the working groups under their Coordinator, to propose future programmes to the Board, and to encourage contact between the members of the working groups.

All interested persons may attend meetings with the approval of the Chairman of the Board.

5.2 While Groups meet by arrangement at times found to be most expedient, the Board will endeavour to meet annually.

5.3 Manuscripts prepared by Working Groups which are ready for publication shall be passed to the Secretary for Publications for submission to the International Coordination Committee for Publications.

5.4 The Committee's budget will be submitted for approval every 3 years to the full session of the Committee.

6. Amendments

The Directory Board will have the power to make provisional changes in the composition and working rules to be presented for ratification at the next meeting of the Committee.

Statuts du Comité de l'ICOM pour la Conservation

1. Le comité et ses buts

1.1 *Le Comité de l'ICOM pour la Conservation* est un comité permanent du Conseil International des Musées.

Ses buts sont entre autres :

- a. d'atteindre et de maintenir le plus haut niveau de la conservation et de l'examen des oeuvres d'art en mettant en contact ceux qui - dans tous les pays - sont responsables pour les biens culturels : restaurateurs, chercheurs scientifiques et conservateurs.
- b. de promouvoir des études scientifiques ou technologiques relatives à cet objectif.
- c. de réunir des données et des informations sur les matériaux et les méthodes d'atelier.
- d. de diffuser les résultats de telles enquêtes par des publications ou autrement.

1.2 *Le Comité de l'ICOM pour la Conservation* est composé d'un *Conseil de Direction* et de *Groupes de Travail* avec leurs *Coordinateurs*.

Les membres du Conseil de Direction et les Coordinateurs doivent être membres de l'ICOM ou le devenir dans les trois mois après leur nomination. Dans les autres cas il n'est pas considéré essentiel d'être membre de l'ICOM.

2. Le Conseil de Direction

2.1 Le Conseil de Direction (nommé le Conseil ci-dessous) est composé de huit membres élus pour trois ans par le Comité et du Directeur du Centre de Rome, qui en fait partie *ex officio*. Les membres peuvent être réélus.

2.2 Le Conseil choisit son Président parmi les membres élus et nomme un Secrétaire Administratif et un Secrétaire aux Publications.

2.3 Parmi les membres élus du Conseil, qui peuvent être également des Coordinateurs, les conservateurs de musée, les restaurateurs et les spécialistes de laboratoire de musée doivent être représentés.

2.4 Des représentants des organisations internationales comme l'UNESCO, l'IIC et l'ICOMOS seront généralement invités à assister aux réunions du conseil à titre d'observateur.

2.5 Le Conseil essayera de se réunir au moins une fois par an.

2.6 Les fonctions du Conseil sont les suivantes :

- a. de nommer les coordinateurs pour des tâches bien déterminées et pour des périodes fixées.

b. d'établir le programme du Comité pour la Conservation en accord avec les Coordinateurs.

c. de contrôler le progrès des travaux.

3. Coordinateurs

3.1 Les Coordinateurs garderont leurs fonctions sous l'approbation du Conseil.

3.2 Le Coordinateur choisit les membres de son Groupe de Travail en consultation et avec l'approbation du Conseil et en dirige les activités.

3.3 Le Coordinateur peut organiser avec l'agrément du Conseil des réunions de spécialistes dans la matière de son ressort, des visites aux laboratoires, sites, etc. directement liées au progrès de son travail.

3.4 Chaque année et trois semaines avant la réunion du Conseil au plus tard le Coordinateur envoie au Secrétariat du Comité pour la Conservation un rapport sur l'état d'avancement du travail de son groupe.

4. Les membres des Groupes de Travail

4.1 Sur la proposition du Coordinateur et avec l'approbation du Conseil, des membres seront assimilés dans un groupe pour l'étude d'un sujet déterminé.

5. Fonctionnement et Finances

5.1 Le Comité pour la Conservation se réunit normalement tous les trois ans en séance plénière pour entendre les rapports sur le progrès du travail exécuté par les Groupes de Travail sous la direction du Coordinateur, afin de proposer les programmes futurs au Conseil et pour encourager les contacts entre les membres des Groupes de Travail.

Toutes les personnes intéressées peuvent assister aux réunions du Comité avec la permission du Président du Conseil.

5.2 Les Groupes de Travail arrangent des réunions aux moments les plus propices ; le Conseil tâchera de se réunir chaque année.

5.3 Les manuscrits préparés par les Groupes de Travail destinés à être publiés seront envoyés au Secrétaire aux Publications afin d'être soumis au Comité International de Coordination pour les Publications.

5.4 Tous les trois ans le budget du Comité est soumis à l'approbation du Comité en séance plénière.

6. Amendements

Le Conseil peut faire des changements provisoires dans les Statuts à présenter pour une ratification à la prochaine réunion du comité.

ICOM Committee for ConservationBy-laws for the Elections of the Directory Board

1. The election of the Directory Board by the Committee takes place every three years during the Plenary Meeting of the Committee.
2. The Directory Board is elected by those present at the Plenary Meeting who have been members of the Committee in the three preceding years.
3. All electors are eligible.
4. Members can put themselves up for election by informing the Secretariat either orally or in writing of their candidacy not later than 24 hours before the election. No candidates can be accepted after this dead-line. Candidates should mention to the Secretariat whether they consider themselves a curator, restorer or scientist.
5. It is not necessary for a candidate to support his candidacy with signatures of members. A provisional list of candidates containing at least sixteen names in alphabetical order is prepared by the Directory Board.
6. The Secretariat prepares a voting-ballot by arranging the candidates in three columns according to their belonging to one of the three categories: curators, restorers or scientists. Each candidate can only appear in one column. Initials and full name of the candidate should be mentioned on the voting-ballot.
7. Prior to the election the Secretariat shall distribute one voting-ballot only to each individual member. The Secretariat shall keep a record of this distribution.
8. Prior to the election a Supervisor of the election is appointed from among the members present as well as two Overseers. The Supervisor opens the voting-boxes and reads the results. These are recorded by two persons appointed by the Secretariat. The Overseers check that the votes are correctly recorded.
9. Each member shall name a maximum of eight and a minimum of six candidates on the voting-ballot by placing a cross behind their names. Each column, corresponding with a category of curators, restorers or scientists should contain at least two crosses. Voting-ballots containing more than eight and less than six crosses are void.

10. Members shall put their individual voting-ballot into a previously sealed voting-box. Voting-ballots should be signed by the Supervisor before being put into the voting-box.
Voting-ballots not carrying the signature or initials of the Supervisor are void.
11. When the time allotted for the voting is expired the voting-boxes shall be assembled and opened by the Supervisor whereupon the public counting of the votes shall proceed.
12. The number of crosses appearing after the names of a candidate is recorded. When all voting-ballots have thus been counted the numbers are added-up.
13. Are being elected first the two candidates who in each column have acquired the greatest number of votes. When two candidates in one category have obtained an equal number of votes and this number is greater than that of any other candidate in that category, they shall both be elected. When three or more candidates in one category have the same number of votes and this number is greater than that of any other candidate in that category two of them shall be assigned by lot. When two or more candidates in one category have acquired an equal number of votes and this number is smaller than that obtained by one other candidate in that category but greater than that acquired by any other candidate in that category one of these candidates shall be assigned by lot.
14. When thus the first six members of the Directory Board have been elected two further members shall be elected from among the remaining candidates, i.e. the two remaining candidates from any category having acquired the greatest number of votes. When two of the remaining candidates have obtained the same number of votes greater than that of any other remaining candidate they shall both be elected. When three or more of the remaining candidates have obtained the same number of votes and this number is greater than that of the other remaining candidates two of them shall be assigned by lot. When the above situations do not occur and two or more remaining candidates have acquired the same number of votes and this number is smaller than that obtained by one other remaining candidate but greater than that obtained by all other remaining candidates, one of them shall be assigned by lot.

Assigning by lot is carried out by the Supervisor according to a procedure of his choice. When more than two candidates from the same country are elected only the two candidates having acquired the greatest number of votes or being assigned by the above described procedure are confirmed. The vacancy thus created shall be filled by applying the procedure described in articles 13 and 14.

- 15. The newly elected Directory Board assumes its functions from the moment that the results are read to the Plenary Meeting by the Supervisor or the Secretariat.
- 16. The Supervisor shall decide in matters arising during the electoral procedure for which these By-Laws do not provide.
- 17. Immediately after the election of the board, a chairman and vice-chairman will be elected. To this purpose the previous secretary will provide appropriate ballots and conduct the election. The person acquiring the largest number of votes will be elected chairman and the person receiving the next largest number will be vice-chairman. In case of a tie for either office a second round of voting will take place between the candidates who have tied.
In accordance to article 13 of the Rules of procedure for the International specialized bodies of ICOM no chairman or member of the Board may remain in office for a period exceeding six consecutive years.
- 18. As soon as possible, following the election of the chairman and vice-chairman, the secretary of the Committee shall be appointed by the board.

The underlined additions to article 9 have been adopted by the Directory Board in its Cardiff meeting of March 1981. They should be formerly adopted by the Plenary meeting of the Committee on 21st September 1981.

Article 17 has been reformulated in accordance with article 13 of the Rules of procedure of International specialized bodies of ICOM.

Comité pour la conservation de l'ICOMRèglement pour les élections du Conseil de direction

1. L'élection du Bureau directeur par le Comité prend place chaque trois ans durant la Réunion plénière du Comité.
2. Le Bureau directeur est élu par ceux présents à la Réunion plénière qui ont été membres du Comité durant les trois précédentes années.
3. Tous les électeurs sont éligibles.
4. Les membres peuvent se présenter eux-mêmes aux élections en informant le Secrétariat, soit oralement soit par écrit, de leur candidature pas plus tard que 24 h avant l'élection. Aucun candidat ne peut être accepté après cette date limite. Les candidats mentionneront au Secrétariat qu'ils sont curateur, restaurateur ou scientifique.
5. Il n'est pas nécessaire pour un candidat de faire appuyer sa candidature par des signatures de membres. Une liste provisoire des candidats comprenant au moins seize noms dans l'ordre alphabétique est préparée par le Comité directeur.
6. Le Secrétariat prépare les bulletins de vote en répartissant les candidats en trois colonnes suivant qu'ils appartiennent à l'une des trois catégories: curateur, restaurateur ou scientifique. Chaque candidat ne peut apparaître que dans une seule colonne. Les initiales et le nom entier du candidat seront mentionnés sur le bulletin de vote.
7. Avant l'élection le Secrétariat distribuera un bulletin de vote à chaque membre individuel. Le Secrétariat tiendra un registre de cette distribution.
8. Avant l'élection un Président de l'élection est nommé par les membres présents ainsi que deux Assistants. Le Président ouvre les urnes et lit les résultats. Ils sont enregistrés par deux personnes nommées par le Secrétariat. Les Assistants contrôlent que les votes sont correctement enregistrés.
9. Chaque membre pourra nommer au maximum de huit et un minimum de six candidats sur le bulletin de vote en plaçant une croix derrière leurs noms. Chaque colonne correspondant à une catégorie de curateurs, restaurateurs ou scientifiques contiendra pour le moins deux croix. Les bulletins contenant plus de huit et moins de six croix sont nuls.

10. Les membres devront mettre leur bulletin de vote individuel dans une urne scellée auparavant. Les bulletins de vote seront signés par le Président avant d'être mis dans l'urne.
Les bulletins de vote ne portant pas la signature ou les initiales du Président sont nuls.
11. Le temps alloué au vote terminé les urnes seront rassemblées et ouvertes par le Président; là-dessus les votes seront comptés en public.
12. Le nombre des croix apparaissant après les noms d'un candidat est enregistré. Quand tous les bulletins de vote ont été comptés, les nombres sont additionnés.
13. Sont élus en premier les deux candidats qui, dans chaque colonne, ont acquis le plus grand nombre de votes. Quand deux candidats d'une même catégorie ont obtenu un nombre égal de votes et ce nombre est plus grand que celui de quelque autre candidat dans cette catégorie, ils seront considérés comme élus ensemble. Quand trois candidats ou plus dans une même catégorie ont le même nombre de votes et que ce nombre est plus grand que celui de quelque autre candidat dans cette catégorie, deux d'entre eux seront tirés au sort. Quand deux ou plusieurs candidats dans une même catégorie ont acquis un nombre égal de votes et que ce nombre est plus petit que celui obtenu par un autre candidat dans cette catégorie, mais plus grand que celui acquis par un autre candidat dans cette catégorie, un de ces candidats sera tiré au sort.
14. Ainsi quand les six premiers membres du Comité directeur ont été élus deux autres membres seront élus parmi les candidats restants, c.à.d. les deux candidats restants de quelque catégorie ayant acquis le plus grand nombre de votes. Quand deux des candidats restants ont obtenu le même nombre de votes plus grand que celui d'un autre candidat restant, ils seront élus. Quand trois ou plus des candidats restants ont obtenu le même nombre de votes et que ce nombre est plus grand que celui des autres candidats restants, deux d'entre eux seront tirés au sort. Quand les deux situations mentionnées ci-dessus ne se produisent pas et deux ou plus des candidats restants ont obtenu le même nombre de votes et que ce nombre est plus petit que celui obtenu par un autre candidat restant mais plus grand que celui obtenu par tous les autres candidats restants, un d'entre eux sera tiré au sort. Le tirage au sort est mis à exécution par le Président suivant une procédure de son choix. Si plus de deux candidats sont élus d'un seul pays, seuls les deux candidats ayant obtenu le plus grand nombre de

votes ou étant assignés par la procédure décrite ci-dessus seront confirmés. Le vide créé ainsi sera rempli par l'application des articles 13 et 14.

15. Les nouveaux élus du Comité directeur assument leurs fonctions à partir du moment où les résultats sont lus à la Réunion plénière par le Président ou le Secrétaire.
16. Le Président décidera en la matière survenant durant la procédure électorale pour laquelle ces lois n'auraient rien prévu.
17. Immédiatement après l'élection du conseil de direction un président et un vice-président seront élus. A cette fin l'ancien secrétaire qui est responsable de tout ce qui se rattache à l'élection, distribuera des bulletins de vote appropriés. La personne ayant reçu le plus grand nombre de votes sera élu président et la personne qui le suit de près sera vice-président. Dans le cas d'un même nombre de votes pour ces deux fonctions il y aura un second tour de votes entre les candidats ayant reçu le même nombre de votes. Conformément à l'article 13 du Règlement des organes internationaux spécialisés de l'ICOM le Président et les membres du Conseil de direction ne peuvent rester en fonction plus de six ans de suite.
18. Le plus tôt possible après l'élection du président et du vice-président, le conseil désignera le nouveau secrétaire du Comité.

Les additions soulignées de l'article 9 ont été acceptées par le Conseil de direction dans une réunion à Cardiff en mars 1981. Ils doivent être adoptés en séance plénière le 21 septembre 1981.

L'article 17 a été modifié conformément à l'article 13 du Règlement des organes internationaux spécialisés de l'ICOM.

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NEW APPLICATIONS OF METHODS OF EXAMINATION

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Programme 1978-1981

Le programme de travail comporte trois types d'activités:

1. Révéler l'apport de nouvelles applications de méthodes d'examen ou de techniques utilisées couramment dans le domaine des musées telles que:

Méthodes d'examen: fluorescence sous U.V.
 photographie I.R.
 réflectographie I.R.
 radiographie

Analyse élémentaire: microanalyseur par source laser
 microfluorescence X
 spectrométrie d'émission U.V.
 spectrométrie d'absorption I.R.
 spectromètre de fluorescence X
 portable

Analyse de structure: diffraction X

2. Améliorer, tester ou adapter de nouvelles méthodes d'examen ou de nouvelles techniques peu ou pas utilisées dans le domaine des musées:

Méthodes d'examen: radioémissiographie
 recherche des critères de qualité
 pour la radiographie des peintures
 enregistrement de microradiographie
 dynamique sur film

stéréoradiographie
 scanning
 holographie
 laser ultra-rouge
 microphotographie I.R.
 mesure tensométrique des toiles

Analyse élémentaire: activation protonique
 spectrométrie par diffraction de neutron
 spectrométrie d'émission
 spectrométrie portable
 spectrométrie de masse (mesure des isotopes du plomb)

Analyse thermique: thermogravimétrique
 thermique différentielle

Datation: amélioration technique de la thermoluminescence

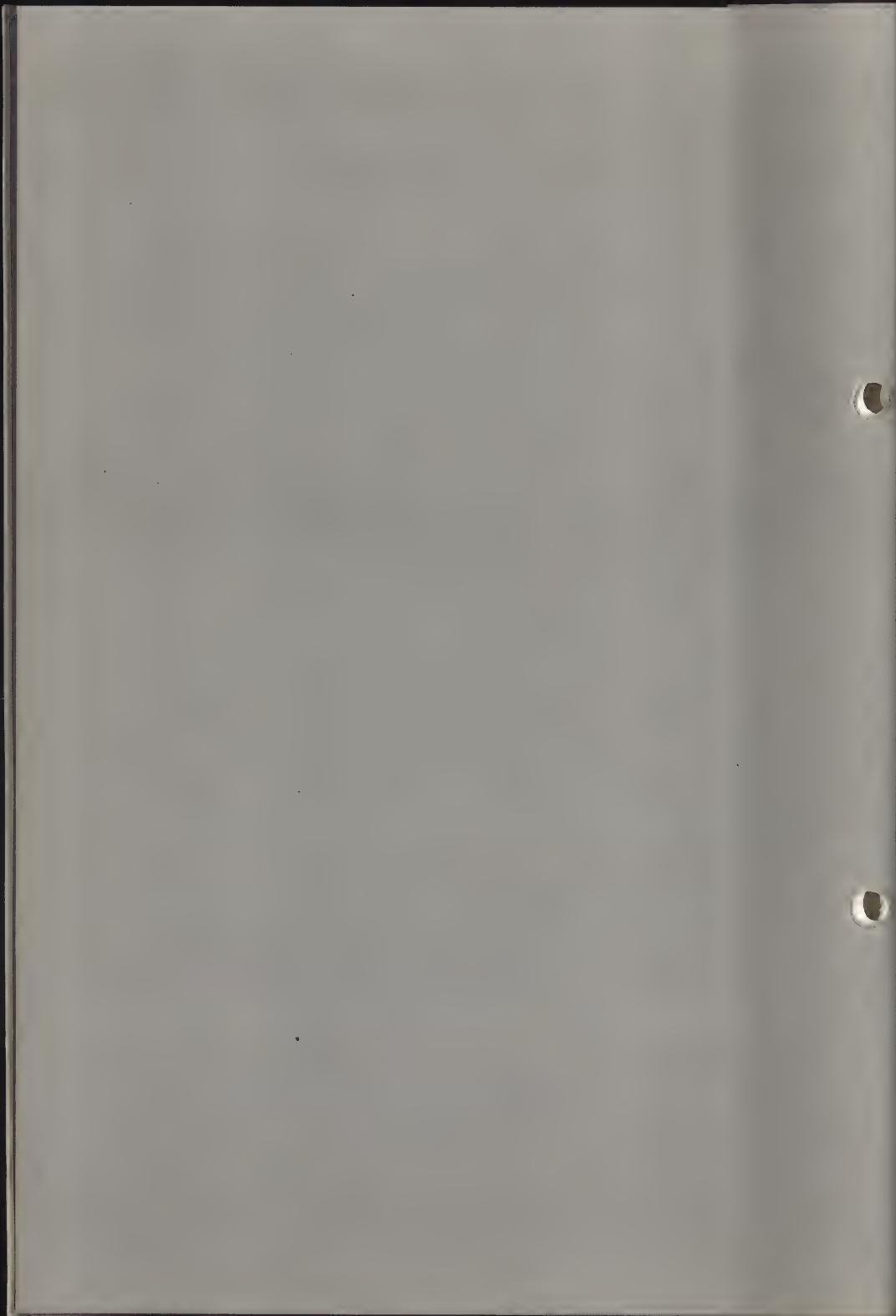
3. Critiquer, développer ou informatiser de nombreux modes d'interprétation des données analytiques.

Les applications des méthodes d'examen et les techniques d'analyse précitées sont extrêmement variées. Elles servent à déterminer l'état de conservation, à caractériser la présence de restaurations, à identifier la nature et la composition des matériaux, à vérifier l'influence du climat, à dater les céramiques et certains métaux, à mesurer le degré de vieillissement de certains composés (huiles ou blanc de plomb), à caractériser les techniques de fabrication des objets et les techniques picturales, à identifier les minerais de plomb, à conserver l'image tridimensionnelle. Ces divers aspects de l'information technique apportée par les sciences justifient l'intérêt d'un tel groupe de réflexion au niveau international pour la conservation des oeuvres d'art.

Sujets proposés

1. Caractérisation et restauration des encres (Mairinger).
2. L'application du scanning dans l'étude des oeuvres d'art (Van Schoute, Hollanders-Favart).
3. Exploitation de nouvelles méthodes d'examen pour l'étude de la peinture flamande du XVème et XVIème siècles (Périer-d'Ieteren).
4. Nouvelles méthodes nucléaires pour l'analyse des objets: Analyse d'objets d'art par activation protonique, - Spectrométrie gamma par diffraction de neutrons de haute énergie (sans radioactivité) (Hanlan).
5. Applications du microanalyseur à source laser pour l'examen et l'analyse des objets de musée (Laver).
6. Applications de l'analyse thermique différentielle et de l'analyse thermogravimétrique au service de la conservation (Scott Williams).
7. Application de la microfluorescence X à l'analyse directe des peintures et des microcoupes (Lahanier).
8. Développement de la microradiographie pour l'étude de la conformation des pigments et de la rhéologie du réseau de craquelures (Percival-Prescott).

9. Enregistrement des microradiographies sur film cinématographique pour étudier la déformation de la surface picturale (Percival-Prescott).
10. Identification et détermination des ions inorganiques par spectrométrie d'absorption infra-rouge (Frediani, Matteoli).
11. Développement de méthodes qui utilisent les films photographiques infra-rouge pour l'examen scientifique des peintures (Matteini).
12. Microphotographie dans l'infra-rouge pour l'identification des matériaux, particulièrement des pigments directement sur le tableau ou sur les coupes (Matteini).
13. Datation de poteries et de fragments de statues par thermoluminescence avec un système amélioré (Ghini).
14. Analyses non destructives des principaux composants élémentaires des bronzes, peintures, poteries... à l'aide d'un nouvel appareil d'analyse portable utilisant la fluorescence X et le rayonnement secondaire Beta - Méthode de datation du plomb des composés du plomb dans les peintures et les poteries à l'aide d'un appareil portatif de spectrométrie Alpha (Sciuti).
15. Application de la spectrométrie de masse à la détermination des rapports isotopiques du plomb pour l'identification des bronzes d'origine chinoise de ceux d'origine japonaise (Mabuchi).
16. Application de la fluorescence X à l'analyse des objets d'art et d'archéologie: limites et possibilités (Von Imhoff).
17. Etude tensiométrique des peintures en tension (exécutées sur les toiles de lin) à la suite des chocs de température et d'humidité (Kuzmitch).
18. Développement des méthodes non destructives d'examen de la structure tridimensionnelle des peintures et des objets d'art (Stéréoradiographie, Holographie) (Museus).
19. L'examen des propriétés optiques de la couche picturale en infra-rouge: diffraction et absorption (Kosolapov).
20. Améliorations dans la méthode de réflectographie des peintures (Kosolapov).
21. Analyse par fluorescence X dispersive en énergie à haute résolution (Kosolapov).
22. Elaboration de critères de qualité et des régimes optimaux pour la radiographie des peintures (Kosolapov).
23. Etude des dessins de fresques du XIV^{ème} siècle par radioémissiographie, sous rayonnements I.R. et U.V. et essai au moyen de rayons ultra-rouges émis par un laser.
24. Développements récents dans l'interprétation des données analytiques des objets en métal (Meyers).
25. L'application simultanée de la spectrométrie d'émission dans l'U.V., de la diffraction X, de la spectroscopie d'absorption I.R., l'analyse thermique et les techniques mathématiques à la connaissance, la conservation et la restauration de la céramique, des pigments et des verres de l'ancienne Egypte et des minéraux de la collection d'histoire naturelle (Čejka).



IN MEMORIAM JOHANNES TAUBERT

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Si Taubert a formé une nouvelle génération de restaurateurs, il a aussi enseigné à de nombreux historiens d'art à intégrer les méthodes scientifiques d'examen à l'étude des oeuvres d'art car pour lui une oeuvre d'art ne peut être bien comprise que si elle est étudiée sous ses trois aspects fondamentaux, son histoire et sa fonction, son processus d'élaboration et son histoire matérielle. Or seule l'intégration des méthodes traditionnelles d'histoire de l'art à l'examen technologique permet d'investiguer ces trois domaines simultanément et de répondre aux trois questions que Taubert posait toujours: qui, pourquoi, comment?

Taubert a créé une méthodologie de science exacte qui constitue pensons-nous le principal message qu'il nous a laissé. Il expose les principes de sa méthode dans la thèse de doctorat qu'il présenta en 1956 à l'Université de Marburg sous le titre de Zur kunstwissenschaftlichen Auswertung von naturwissenschaftlichen Gemäldeuntersuchungen. Les recherches qui constituent la base de cette thèse ont été menées au laboratoire central des Musées de Belgique (IRPA). En effet après un stage bénévole au Doerner Institut de Munich, Taubert obtient une bourse pour travailler à l'IRPA. Il arrive au laboratoire de Bruxelles au moment où s'achève la restauration et l'examen scientifique de l'Agneau Mystique et s'intéresse à la documentation technique rassemblée par le laboratoire et en particulier aux photographies dans l'infra-rouge.

Dépasant l'examen analytique, il montre que l'interprétation des données fournies par les différentes méthodes scientifiques d'examen permet de reconstituer le processus d'élaboration des oeuvres, ce que Taubert appelle la peinture en devenir, et de caractériser ainsi la manière de chaque peintre.

La démarche de Taubert est dans la ligne de celle suivie par son maître Ch. Wolters qui avait retracé le processus de réalisation d'un tableau à l'aide de l'examen des rayons X. Taubert élargit le champ d'investigation de son maître aux diverses méthodes qui étaient alors couramment employées.

La méthode scientifique d'examen exposée dans la thèse de Taubert, la terminologie technique définie pour la première fois avec rigueur, comme l'interprétation des dessins sous-jacents chez Van Eyck, Memling et Bouts restent un modèle du

genre auquel tous les chercheurs se réfèrent constamment. Par ce travail et ses recherches ultérieures Taubert ouvrait une nouvelle voie aux historiens d'art qui jusqu'à lui se contentaient le plus souvent d'un simple relevé de faits sans tenter d'interpréter les données nouvelles en fonction des problèmes précis posés par l'oeuvre.

Si Taubert a proposé aux historiens d'art d'user d'une nouvelle méthode de travail, il a aussi apporté à ceux qui ont eu la chance de le connaître, et principalement aux jeunes chercheurs, une éthique du métier basée sur la conscience des possibilités et des limites de l'information que l'on peut attendre des méthodes d'examen, sur une source d'analyse rigoureuse et une volonté de justifier toute hypothèse par un triple raisonnement d'ordre technique, artistique et historique, inséparable pour lui lorsqu'on parle d'histoire de l'art au sens large du mot.

J. Taubert a toujours voué une attention particulière aux jeunes chercheurs. Il était ouvert à tous les problèmes qu'ils venaient lui soumettre et y répondait toujours avec la même érudition, la même sensibilité, la même simplicité et la même gentillesse innée.

Toute question pour lui méritait une réponse ... et si elle était sujette à des développements, Taubert s'y livrait avec l'enthousiasme qui le caractérisait et qu'il communiquait si facilement.

Le souvenir de J. Taubert restera pour beaucoup d'entre nous celui d'un pionnier qui a assimilé les sciences exactes dans l'histoire de l'art, celui d'un esprit éveillé constamment à l'affût de nouvelles découvertes et expériences, et enfin celui d'un homme toujours prêt à faire profiter les autres de son savoir et de l'état de ses recherches, ceci afin que la science de l'art qui lui tenait tellement à coeur ne cesse de progresser.

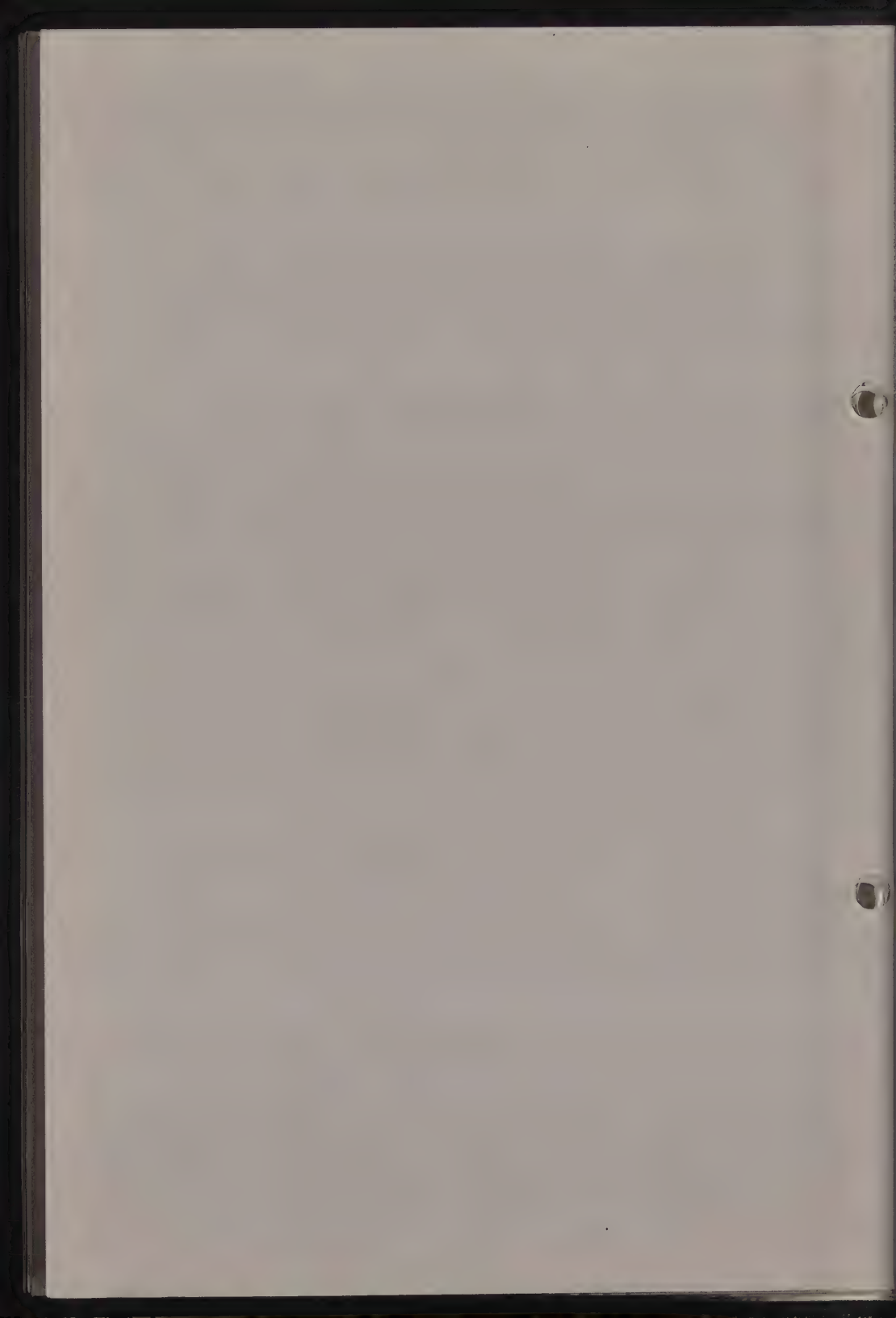
L'hommage que nous lui rendons ici est de continuer dans la voie qu'il nous a ouverte et de faire en sorte que d'autres nous y rejoignent.

X-RAY STEREOGRAPHIC INVESTIGATION OF
WORKS OF APPLIED ART

L.A.Museus and A.N.Cherny

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: New Applications of Methods
of Examination



X-RAY STEREOGRAPHIC INVESTIGATION OF WORKS OF
APPLIED ART

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When objects of applied art are investigated and restored, the determination of their preservation and the technology of their production are of particular interest. The X-ray method of investigation is the most effective in this case, for it is nondestructive, simple enough and can be employed even in field conditions.

It is known from museum practice that the examination by X-rays enables one to obtain information about the presence of certain nonuniformities, such as cracks, cavities, parts of materials, traces of mechanical damage and treatment etc.; by this method it is possible to determine the character of joints and the macrostructure of the material. As one can see from the list of problems most of them concern the investigation of the three-dimensional (3-D) structure of the object and thus can be solved by X-ray stereo- and X-ray stereogrammetric methods.

Recording can be carried out by conventional X-ray sources. In some cases the X-ray source is sequentially placed at two discrete positions during the process of recording it the design of the support is suitable, in other cases the object of investigation turns about its axis when the position of the X-ray source does not change.

The examination of the topography of the internal surface and structure of optically opaque objects requires some check points. To reduce errors and to increase the accuracy of measurements it is advisable to have a whole set of check points with the known height marks. These check points in the form of leaden balls with 0,2 mm diam can be attached to the external surface of the X-ray cassette by using the micrometer to measure their distance from the X-ray film plane. Measurement of the position of individual image details relative to the nearest check point can be conveniently made on the stereocomparator STR-3 produced by Opton firm, or on the Zeiss stereocomparator.

By using simple formulae /1,2/, in this way one can determine the dimensions of the object's internal surface, the position of cracks, and reconstruct the three-dimensional model of plastic deformation in metal or ceramic mass.

However, to reconstruct three-dimensional X-ray image one needs a special device - stereoscope. This method of observation often tires the researcher and is not always available for use in museum laboratory.

For this reason the interest has been lately aroused in holography and lenticular - sheet (LS) picture which enable to observe the 3-D image by the naked eye. But the processes of X-ray holographing and X-ray lens-sheet picture taking are extremely complicated and practically inapplicable in restoration laboratories.

As is known /3/, the optical lenticular sheet is a transparent plate consisting of numerous plano-convex cylindrical lenses which are placed close to one another. The thickness of the LS has been assumed to be chosen so that the focus of a parallel incident beam is formed upon the surface of LS backed by photographic emulsion. The emulsion is exposed to the

beam, developed and then illuminated from the back to reconstruct the image. The incident beam is formed upon the emulsion strips. The arrangement of these strips depends on the direction of beam's incidence.

The analysis of the LS picture taking process enabled to applicate a simplified method of printing of X-ray negatives. In this case X-ray negatives made for stereogrammetric measurements are sequentially projected onto an lenticular sheet backed by photographic emulsion of the film and exposed to the beam of the point source. The angle of illuminating corresponds to the angle of X-ray recording. Reconstructed 3-D image is directly observed by the naked eye through the same lens sheet overlayed on the exposed and developed film. The observer's eyes should be located at the viewing points corresponding to the points of printing.

It is found that the optimum dimensions in the LS picture-taking process are follows: the focal length of the X-ray tube is 100 cm; the distance between the light source and the lens sheet is 25 cm; the stereobasis of X-ray recording is 20 cm; the stereobasis of printing equals to the average human eye separation 6,4 cm.

To complete the LS picture one can use fine-structure lens sheets of 13x18 cm size that are used in polygraphic industry for postcards and publishing advertisements, high contrast photo films and a slide projector as a source of light.

During printing the projector inclines to the left and to the right at an angle corresponding to the stereobasis 6,4 cm.

LS pictures made by this method can be published in many copies, served as illustrations or be demonstrated at lectures.

Thus, two marked X-ray stereograms enable the researcher follow:

1. to examine visually the internal three-dimensional structure of the work of art by means of the stereoscope.

2. to estimate the three-dimensional position of individual points or elements of the object relative to the plane of X-ray film by means of the stereocomparator.

3. to print lenticular sheet pictures which make it possible to observe X-ray three-dimensional images by the naked eye without the stereoscope.

The above-mentioned methods widen the possibilities of investigation the preservation as well as the authenticity of works of applied art, they enable the researcher to compare technological characteristic properties of numerous works.

1. Museus L.A., Cherny A.N., Protsenko E.M. The use of the stereophotogrammetric method in the X-ray investigation of objects. "Proceedings of higher educational institutions. Geodesy and Air Photography", 1978, N 3.

2. Cherny A.N., Protsenko E.M. The use of X-ray stereogrammetric method in the investigation of plastic deformation in metal. "Proceedings of higher educational institutions. Geodesy and Air Photography", 1978, N 6.

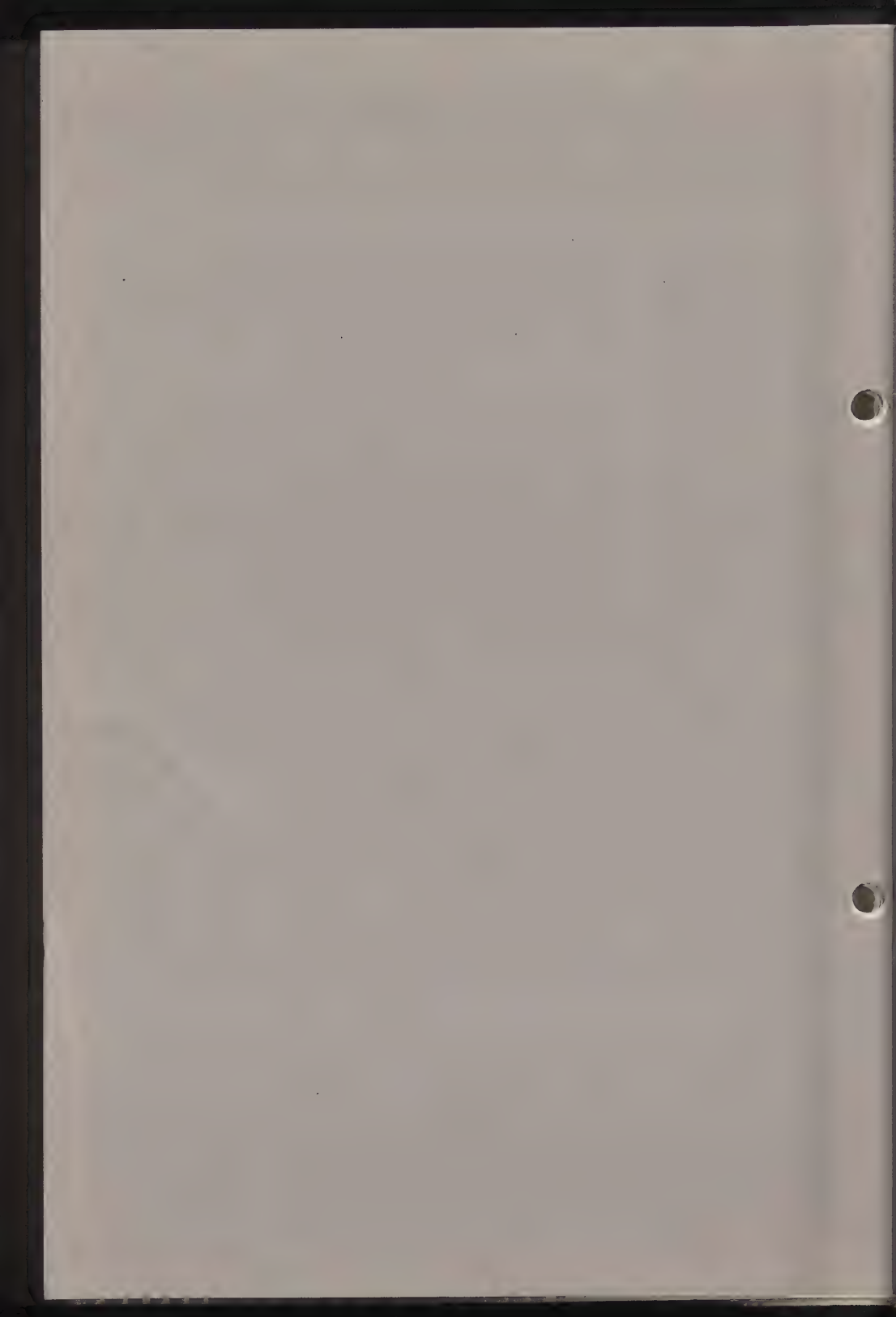
3. Valus N.A. Stereoscophy, London, 1967.

WIDE FIELD CONTACT PHOTOMICROGRAPHY OF
WORKS ON PAPER

Westby Percival-Prescott

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: New Applications of
of Examination



WIDE FIELD CONTACT PHOTOMICROGRAPHY OF WORKS ON PAPER

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Great Britain

Abstract:

Of all the common methods of examination, the enlarged image is generally considered to be one of the most useful. But in many cases the degree of enlargement limits the value of the information as work at higher magnifications must by necessity be restricted by a narrow field of view. Widening the field has proved difficult. Recently introduced microfiche techniques have enabled smaller images to be magnified maintaining high resolution. This Paper describes methods of making wide field contact photomicrographs and the various new ways they can be studied to advantage.

The introduction of commercial high resolution film⁽¹⁾ some years ago gave us the possibility of magnifying a photographic image to higher limits than previously possible. One simple use of this film is direct contact printing from drawings. A perfectly satisfactory image can be produced in negative form from a contact print of a drawing and this negative can be enlarged to give useful magnification up to 100X. A vacuum controlled contact printer is required. There are many types in existence. The best of these have the means of producing rapid vacuum and release, a timed exposure and a diffuser.

To obtain a fine detailed image from the film at this magnification requires an instrument of the type described in my previous ICOM Paper, 75.4.1, or the making of further enlargements on to high resolution film. They cannot, however, be made without a copying camera and special equipment. The camera which has been built for the Conservation Department of the NMM has, as well as the normal focusing mechanisms, a fine micro focusing attachment. This control is housed at the back of the camera and enables the operator to focus using a 5X screen magnifier. A light box is necessary and light is transmitted evenly through the high resolution film to produce a satisfactory image. It is important that the film being copied is not affected by heat during the process as dimensional stability is essential during the period of exposure.

The stability of the camera is another important requirement and the higher the magnification required the greater this problem becomes. The camera referred to is housed for this reason onto a heavy slab of compressed asbestos. Stone or concrete could also be used for this purpose. The slab rests on a robust wooden cabinet to ensure that no residual movement occurs. Any movement connected with the handling of the equipment is minimised by the shock absorption of the wooden components. It might be noted that direct magnifications of over 100X are usefully obtained with suitable lenses. These can be obtained from the principal makers of microscopes.

Using any relay copying system where the image is copied on to another film at a higher rate of magnification gives an opportunity for contrast reduction or intensification. Photo mosaics can also be made and the overall field of view can thus be extended still further. A large light box is essential if the mosaic is to be made using photographic film but the value of the wider tonal transmission coupled with higher resolution obtained makes the use of film worthwhile. We have all grown accustomed to micro cross-sections providing significant information within the limitations of their field. Contact photomicrography cannot provide the kind of information which one obtains from a paint micro cross-section but it does offer what might on occasions be more valuable, i.e. the possibility of interpreting the section in a wider physical context covering an area of over a million times that of the cross-section at a similar magnification.

The method of making the contact image is a comparatively simple one:

1. First examine the drawing and determine the area of interest which cannot exceed 10" x 8", the maximum size of the film.
2. Place the drawing face up on the clean glass surface of the contact box.
3. Select the area of the work which you wish to examine in closer detail. Then in darkened conditions, but with use of an X-ray safe light Kodak No. GBX, place the unexposed film, emulsion side down, to rest on top of the area of the drawing under consideration. A thin sheet of melinex can be superimposed between the drawing, the film and the lid of the contact box.
4. Carefully close the lid to minimise the risk of movement of the drawing or the film. Lock the lid into place and raise the vacuum to the normal level used for the copying.
5. Expose the film by switching on the lightbox for an appropriate period of time. (The length of time can only be determined by trial and error and depends on the power of the illuminating source and the density of the paper and drawing. A typical example on 17th century thin laid paper with line drawing or watercolour requires 15 secs. exposure. A drawing on thicker paper with secondary support would require 15 minutes. Both examples could be equally successful.
6. Develop the exposed film in a technical developer of high contrast. Suitable developers are Kodak DX80 or Teknol made by May & Baker, Dagenham. Development can be carried out under dim safelight conditions.
7. Develop the film for the recommended period. The type and strength of the developer must also be determined by trial and error. After half the period of normal development, raise the film from the tank or tray and view it against a light surface under conditions of the safelight, and estimate the final density that is required. For high magnification a dense negative is valuable but should the requirement be for a positive image using high resolution film to also provide the positive image, a lighter and more balanced tonal range would be required for the negative.

8. After the completion of the development, wash the film thoroughly. The film can be fixed in any general photographic fixer. Ensure that the fixing time is fully met and follow this stage by prolonged washing, doubling the time normally required. Dry naturally or in drying cupboard conditions.
9. Protect the film by placing it in a transparent sleeve, marking clearly on the outside the information about the drawing. Number the film directly onto the edge of the negative.
10. The negative image which results from this treatment can be judged in similar terms to radiographs. The image is dependent on the limitations of light transmission but not necessarily density which is the case of the radiograph. Techniques for examining the film have been described in a previous Paper published in ICOM Pre-Print No. 78.1.5.

The Examination Technique

The image which is made on the film, which under general observation might appear too dense and difficult to interpret, can be now enlarged up on a microfiche reader⁽²⁾ to a convenient magnification for interpretation. Common magnification ranges may be from 10X to 20X. Some of these have facilities to produce even higher magnification, 40X viewing, under intense light illumination. The resultant images provide far more detail than any possible photographic print, as the tonal potential of the film is much greater than the paper print. The provision of a control to move the stage which normally holds a microfiche enables one to select an area from the overall field and gives an opportunity of rapid scanning at both magnification ratios.

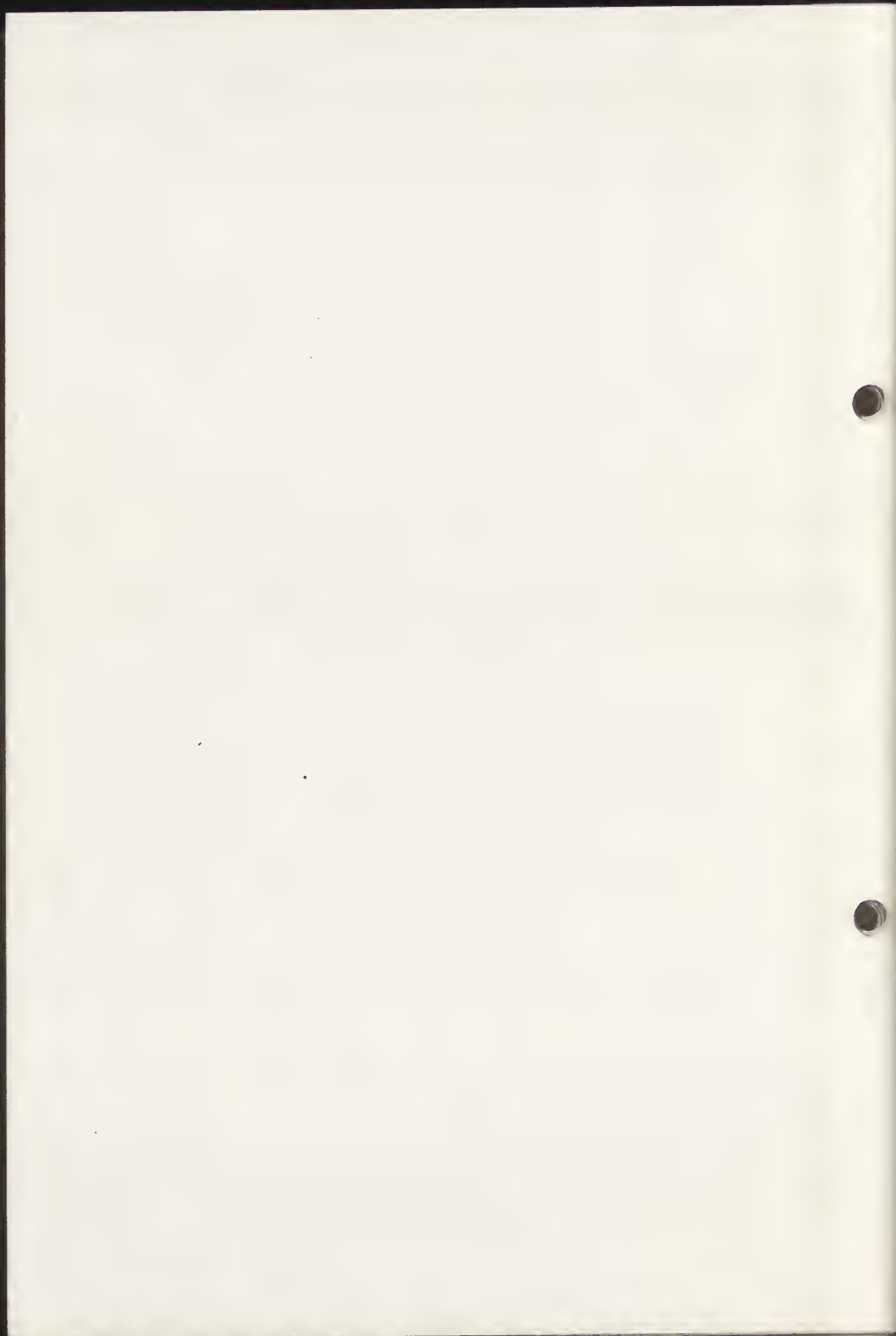
The magnification capabilities of high resolution film using the technique referred to far exceed any other commercial photographic film and under special conditions can be more than 100X but fail beyond 150X. This range of magnification is a very convenient one as it corresponds to a typical magnification range used by many researchers engaged in examination of paint micro cross-sections. It thus allows direct comparisons to be made. The information gained from the paint sample and the photomicrographic image at similar magnification. If a radiographic source is used, this greatly increases resolution and the depth of field and avoids to a much greater extent the penumbra effect.

This technique can provide clear images of pigment distribution on the face and reverse of the drawing, even when backed, define nature of losses and give precise pattern characteristics of laid paper. It is a simple and rapid method offering information of use to the professional and the informed layman.

- (1) Kodak High Resolution Film SO/343, Cat. 192.9074
- (2) Microbox MLK Readers made by GAF (Great Britain) Limited, 1 Kingsway, Aldwich, London.

Acknowledgments:

Research for this Paper has been carried out with the kind assistance of the staff of the Conservation Department, National Maritime Museum.



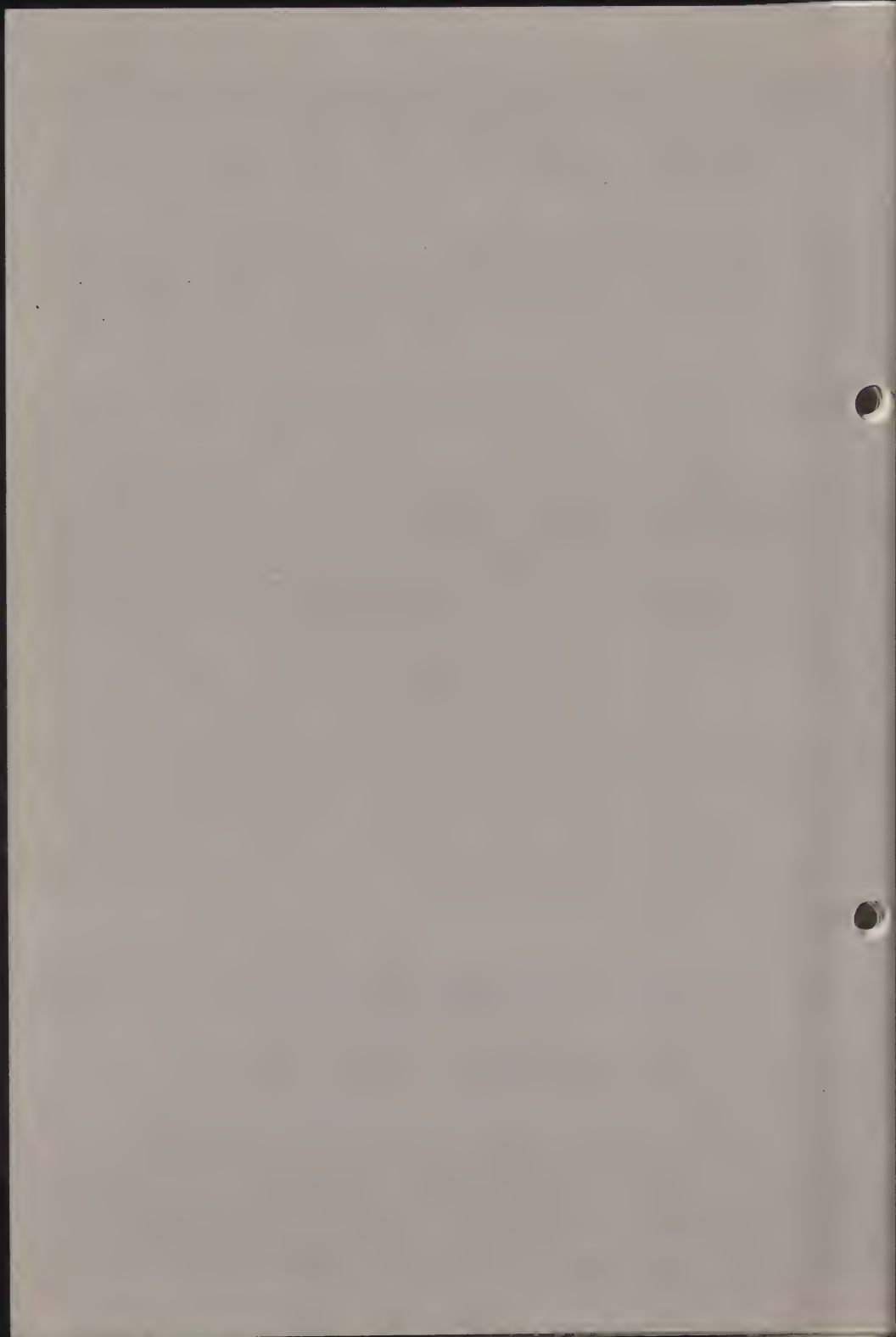
81/1/3

INFRA-RED REFLECTOGRAPHY OF PAINTINGS.
THEORETICAL AND EXPERIMENTAL RESEARCH

A.I.Kosolapov

ICOM Committee for Conservation
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Working Group: New Applications of Methods
of Examination



INFRA-RED REFLECTOGRAPHY OF PAINTINGS., THEORETICAL AND
EXPERIMENTAL RESEARCH

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Abstract. The results of theoretical and experimental research of the problem of revealing hidden images on paintings in the infra-red are discussed in this paper. Experimental estimates of the spectral absorbance of paints have resulted in defining the intervals of IR-region where the paints may be considered as pure scattering systems.

Thus a theory has been built which satisfactorily explains the main experimental results observed in IR-reflectography of paintings. The theory seems to suit for the purpose better than the application of the Kubelka-Munk approximation used in Van Asperen De Boer works of 1968-1974. Some types of IR-reflectographical systems commonly used for studying paintings are examined critically. Some new lines of the development of IR-reflectographical equipment are described.

Investigation of paintings by means of reflected infra-red radiation is based on the following properties of paints: they let pass, absorb and scatter the falling IR-radiation in not in the same way as the visual light. These phenomena permit to get more information about paintings: e.g. to reveal the changes of composition, the under-drawing, the author's signature which

had faded away etc.

Some practical aspects of photography of paintings using IR-photoemulsions as well as IR-images converters have been described both in this country and abroad.

In the works of Van Asperen De Boer in 1969-74 the first attempt to apply a theory explaining the principles of the optical behaviour of paints in the infra-red was made as well as to build a theory about revealing hidden pictures.

These works by Asperen De Boer have some basic drawbacks. Thus the Kubelka-Munk theory can practically be used for describing the integral passing of the radiation energy through the layer of paint. Whereas when dealing with the problem of revealing optical images one must concentrate only on the radiation flow spreading according to the laws of geometrical optics in small angles. This unfortunately leads to the following consequences.

Let us assume that on a diffusion reflecting surface with a Lambert's indicatrix of brightness there is an item reflecting almost mirrorlike, the integral coefficient of reflection of the surface and of the item being equal. According to the Kubelka-Munk theory the contrast of such an item in the reflected radiation equals to zero, the integral flow of radiation reflected from the surface and from the item being equal. However if a reflectographical system with a small aperture is used for revealing an item, it can have a contrast of the order of 1, as a large part of radiation reflected from the surface does not go into the receiver. But the radiation reflected by the item completely passes into the receiver.

Another serious drawback of De Boer work is his failure to consider the physical aspects of the optical behaviour of paints in the infra-red. For instance the main problem of the reason of the increase of the transmission coefficient of paint with the increase of the wave length is not considered at all.

These drawbacks in theory resulted in wrong conclusions. For example, the conclusion that for revealing the under-drawing the optimal wave length is $\lambda = 1.8\mu$ is erroneous. In experimental IR-reflectography as a whole this conclusion has not been proved to be correct.

The author of this paper has carried on theoretical and experimental research in 1975-1979. This research work has resulted in a new theory of IR-reflectography. The aim of this paper is to draw a number of conclusions as a result of our research work, and thus to give a modern formula of the basis of IR-reflectography, including a comparative analysis of modern systems of

transformation of the IR-image into a visual one, the systems to be used for IR-reflectography of paintings.

1. In the nearest IR $\lambda < 2,7\mu$, (and also in a further removed IR-region) in the case of absence of bands of self absorption of the media and pigments, the paints and grounds may be considered as pure scattering systems. The proper spectral characteristics have proved to be defined by ratio λ/λ_0 ^{x)} (in normal values of oil capacities) where:

$$\lambda_0 = \pi x_0 (n-1) \quad (I)$$

x_0 - is the average size of particles of the pigment in paint; n - is the refraction index of the pigment in relation to the medium.

The transmission coefficient of the paint layer measured in a small body angle was shown to increase with λ at the first approach linearly as λ/λ_0 , if $\lambda/\lambda_0 < 1$. If $\lambda/\lambda_0 \geq 1$,

the slope of the spectral transmission coefficient curve is proportional to $\exp - \{\lambda/\lambda_0\}^2$. So the effective rise of paint transparency takes

place until $\lambda/\lambda_0 < 1$. Thus for a layer of finely grained ochre ($n=1,3$; $x_0 \sim 1,5\mu$) λ_0 appears to equal to $1,5\mu$ and, accordingly the maximum of transmission is reached already at $\lambda \sim 1,5\mu$. This as a matter of fact explains the practical success achieved at revealing the underdrawings on the pictures of German and Netherland primitives with the help of IR-photography, that is at $\lambda \leq 1,1\mu$.

The same advantage can be achieved using the parameter λ/λ_0 to describe the properties of dimmed varnish, the process of dimming being the result of the accumulation of numerous microcracks in the varnish film as scattering centres.

x) Strictly speaking, the transmission and reflection coefficients connected with the coefficient of scattering are formulated in special functions depending on λ/λ_0 , x_0 , λ_{min}/x_0 where x_{min} is the minimum size of a particle. The particles sizes according to measurements have proved to be adequately described using the Rozen-Ramler distribution. the value of the distribution parameter being $\rho = 2$. Besides, λ_{min}/x_0 depends quite negligently on the time of comminution of the pigment and equals to a value 0.1-0.3. However the wave length of the initial radiation enters the theory only as a parameter λ/λ_0 .

2. In revealing images, items hidden by the top layer of paint on paintings, the following cases can be observed in the IR-region: x)

2.1. $T_0 \ll T$, where T_0 is the transmission coefficient of the hidden item, T is the transmission coefficient of the hiding paint layer.

In this case the contrast of the item to be revealed increases continuously as the wave length of the falling radiation grows.

2.2. $T_0 \approx T$

The analysis of this case proves that the largest value of the contrast is achieved with the value of the wave length λ_{max} , whereas $T(\lambda_{max}) = 0,68$. The case 2.2 includes Asperen De Boer's result with $\lambda_{max} = 1,8 \mu$.

2.3. $T_0 \gg T$

The item as a rule in the IR can't be revealed, as its contrast value appears to be $\sim T^3 \ll 1$. The existing systems for IR-reflectography don't have the desirable contrast sensitivity for registering such items.

3. An interesting use of IR-radiation as mentioned earlier in this paper is for revealing the initial author's drawing under the paint layer. We have already stated that most of the charcoal drawings from the point of view of contrast spectral dependence is in the line of case 2.1. The contrast of such drawings on gypsum chalk grounds can be formulated by the relationship:

$$K = 0,2 T^3 \quad (2)$$

T is the transmission coefficient of the paint layer hiding the underdrawing.

Considering the magnitude of the relationship signal/noise \mathcal{L} of the reflectographical system for revealing the underdrawing the following condition should be valid:

$$T \geq 1,71 \mathcal{L}^{-\frac{1}{3}} \quad (3)$$

The relationship (3) shows that the larger the relationship signal/noise in the system, the smaller the values of the transmission coefficient and so the smaller the values of the wave lengths may be used for revealing the hidden underdrawing.

x) In the theoretical analysis of the expression for the contrast of items to be revealed it was assumed that the ground of the painting was much thicker than the paint layer and the items themselves which is correct for most of the pictures.

For IR-films it would also be recommended to introduce the term signal/noise ratio. According to our measurements the main contribution to the "noise" in the IR photoemulsions of this country results in non-uniform blackening of the photoemulsion in the given part of the negative, that is amounting to about 10 per cent (of the value of the optical thickness of the blackening). And so it may be shown that the relationship for contrast sensitivity is:

$$R_{\min}^{-1} = \gamma \approx 22,2 \quad (4)$$

γ is the contrast coefficient of the photoemulsion.

For the infra-red films I-I030, I-I070 mostly used in the Hermitage laboratory $\gamma = 2.0$, that is $\gamma = 45$ which is two times higher than the common IR television reflectographical system contrast sensitivity. Thus on the same wave length the hiding thickness of paint^{x)} is 1.4 times larger for films than for IR television systems with $\gamma \sim 20$.

All this leads to the conclusion that infra-red films in their spectral sensitivity ranges have more advantages in their reflectographic capacities than the IR television systems. The more so that the resolution of the films is much higher. (See Table I later in this paper).

Some technical data for the IR television systems operating at the Hermitage and Russian Museum laboratories are given in Table I. In the same table the data of the film I-I070 used in the standard for this country museums camera FKD 13x18 with objective lens I-51 are shown for comparison.

4. Observing the paint coat spectral transmittance gives evidence that for the IR-reflectography of paintings the following wave length range in microns is recommended: (0.7+2.7); (3.1+3.2); (3.5+5.5), as they don't contain strong bands of absorption of medium groups CH_2 , CH_3 , C=O .

The optimal spectral ranges for operations with paintings has proved to be only the range (0.7+2.7) microns, whereas the optimal for reflectography in this range are television systems using IR-vidicons.

This conclusion seems to be contradictive as the estimation of the value according to the relationship (I). Also in experiments the observed spectral transmission curves show that for high refracting paint (lead white, massicote) the greatest value of

x) The hiding thickness means here the thickness of the paint layer under which the item with contrast 0.4 can still be revealed.

transmission coefficient is reached in the region

$\lambda \sim 5,5\mu$; the last region at first sight seeming optimal for IR-reflectography. For image transformation in this region thermographs and thermovision devices should be used.

However, the reflection coefficient for a gypsum chalk ground of normal thickness, measured in the small body angle, which corresponds to the angle aperture 6-8 of the television system objective lens appears to be not larger than 0.002 and, besides, approaches the reflection coefficient of the material the underdrawing is made with (charcoal, smoke-black etc.).

This is the reason of our failure in the attempts to reveal the drawing on specially prepared samples of painting by means of a rather sensitive thermovision device AGA-680, although the permissive limit of irradiation for paintings was overpassed. It should be noted that on the same samples the drawing was well revealed by means of a IR-vidicon television system, at

$\lambda \sim 1,8\mu$ with normal rates of irradiation.

If however we assume that due to manifold increase of one raster scanning time by the thermovisual device and increasing the sensitivity, the picture can be revealed in the region of maximum transmission of the paint layer, then the system working in the thermal region has one more great disadvantage - low optical resolution, usually not more than 5×10^4 elements of the image in one raster.

If we consider that for a satisfactory production of the drawing it is necessary to have the resolution of 2 - 3 optical lines per mm in the field of objects, then one raster holds 10 x 10 cm piece of the picture. Thus for a relatively small picture 100 x 100 cm about a hundred reflectograms will have to be taken by means of a thermograph, which will take dozens of hours.

The same consideration holds for spectral intervals $3.1+3.2\mu$, $(3.5+5.5)\mu$, for the only suitable kind of IR-reflectographical system operating in these intervals is a thermograph with detector of the In Sb type. But as Aspergen De Boer has shown, in the region $\lambda \sim 2,0\mu$ for 2.4×10^5 elements of the image to be resolved by means of a Barnes - T4 thermograph it took 27 minutes (!). For comparison it is interesting to note that with the IR-vidicon TV system at $\lambda \sim 2,0\mu$ with the resolution of the same order one shot can be taken in a few seconds.

5. At present tendencies are envisaged toward developing vidicon TV systems for IR-reflectography of paintings.

First of all it is important to point out the direction in the line of introducing videosal signal filtration in scope frequency. A lot of experimental data has been accumulated indicating the advantages of such filtration. As a matter of fact we have observed that the rise of high frequency amplification results in a marked better videotransmission of underdrawing revealed under a paint layer.

The greatest effect in revealing hidden pictures should be produced by "subtraction" from the IR-image of the picture the visible picture, initially weakened and properly balanced according to contrast.

Another line of development of IR-reflectography technique is in the line of higher contrast sensitivity reached by means of increasing the relationship signal/noise. The latter can be achieved using special operation regimes of the transmitting tubes.

The modern engineering development is bringing the appearance of many kinds of new modifications of transmitting tubes, sensitive to the IR - field of the spectrum. Thus recently the spectral sensitivity of some industrial types of IR-vidicons approaches

$\lambda \sim 2,5\mu$. The resolution is not less than 700 lines on the target for a one-inch vidicon. Matrix video transformers also seem to be advantageous. However up till now their resolving power is not higher than 2×10^4 image elements which is clearly not enough for IR-reflectography of paintings.

The common disadvantage of IR-vidicons is the high irregularity of a target dark current and numerous dot defects due to the absence of a good technology of targets production. Introducing correction impulses of a shading generator may result in a slight stabilization of a target dark current and the corresponding improvement of the image. As a matter of fact the shading generator was used in the last type of IR-vidicon TV system introduced in the State Hermitage.

Table I. IR-reflectographic properties of TV systems and IR photoemulsions.

Characteristics	TV system with IR image orti- con tube	System with IR vidicon tube	Infra-red film of I-IO70 type
Spectral sensi- tivity up to $\lambda_{\max} (\mu)$	I.1 - I.2	2.0 - 2.4	I.15
Signal/noise ratio	20	17 - 20	45
Resolution (num- ber of elements of image in one raster)	2×10^5	2×10^5 if $\lambda = 0.6 \mu$ 1.4×10^5 if $\lambda = 2.0 \mu$	2×10^5
Number of trans- mitted gradua- tions of grey according to vi- deo test 0249	8 - 9	7	6 - 7 (contrast coefficient $\gamma = 2.0$)
Illumination of the picture, lk. Illumination with incandes- cent lamps with $t_0 = 2,850^\circ K$	70 - 100 if $\lambda = 0.8 \mu$ 700-800 if $\lambda = 1.0 \mu$	500 if $\lambda = 1.6 \mu$ 2,000 if $\lambda = 1.8 \mu$	500 if expo- sition is 20 min., relative opening 1:8, filter is glass IKS-3, thickness 3mm
The hiding thick- ness in microns for ochre and white lead, (average grain size $x_0 = 3.0 \mu$)	ochre-50 lead white-10	ochre-125 lead white-25	ochre-70 lead white-14

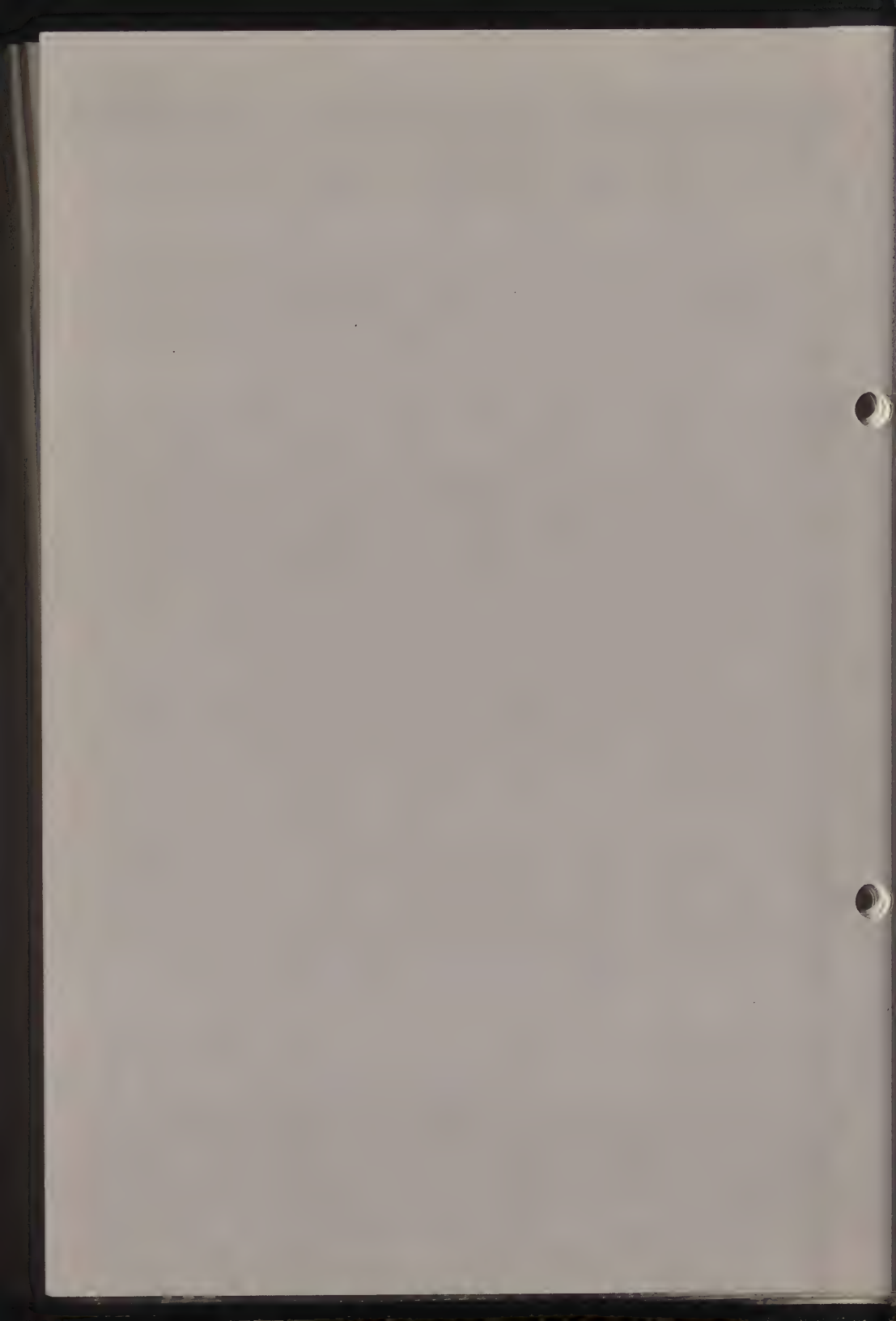
81/1/4

CLUSTER ANALYSIS AND ITS APPLICATION IN
MUSEUM CHEMISTRY AND CONSERVATION

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ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: New Applications of Methods
of Examination



CLUSTER ANALYSIS AND ITS APPLICATION IN MUSEUM CHEMISTRY
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A b s t r a c t

Q-mode cluster analysis of nonquantitative data has been demonstrated on a set of ceramic samples (pottery) from an archaeological locality in Egypt which had been analysed by optical emission spectroscopy before it was classified.

A similar procedure for classification of a large set of analysed specimens which has been described by qualitative or semiquantitative characters could be applied with benefit also in the field of conservation and restoration of museum collections.

I n t r o d u c t i o n

Examining the collected objects in museum, eg. ceramics (pottery), glass-ware, metal-ware, pigments etc. in order to prepare them for conservation, restoration or for scientific reassessment, we often meet the necessity to treat large sets of data.

If the objects are characterized by several parameters and only by qualitative or semiquantitative characters, it is difficult to find relations among the studied samples, which would enable to classify them into groups with common characters. The use of statistical procedures realized by computer technique is appropriate for that purpose. One possibility for solution similar problems is to apply cluster analysis / DURAN, ODELL 1974/. The methods of cluster analysis have been already used with success eg. in archaeological studies /GILMORE 1980, SCHWABE, SLUSALLEK 1980/.

Working procedures

Let us consider, we have n samples which are described by m characters. If the number of samples is large and they are characterized by several parameters, it is getting difficult to classify them "by eye". We use common iterative procedures for the grouping of samples / PARKS 1966 / eventually discriminant function is applied as a criterion in the optimization / CA-SSETTI 1964 / for quantitatively expressed data. The similarity coefficient used to be a standardized Euclidean distance of m -dimensional space

$$d_{ij} = \left[\frac{\sum_{k=1}^m (x_{ik} - x_{jk})^2}{m} \right]^{1/2}$$

where x_{ik} and x_{jk} is parameter k measured on the sample i and j resp. The lower is the coefficient the more similar are the samples.

In case of a treatment of samples specified by semiquantitative or qualitative data, we use another kind of similarity coefficient for cluster analysis, eg. Sokal-Michener similarity coefficient

$$S_{SM} = \frac{p + n}{p + n + m}$$

or

Jaccard similarity coefficient

$$S_J = \frac{p}{p + m}$$

where p = number of positive matches between characters

n = number of negative matches between characters

m = number of mismatches between characters

A full agreement gives $S=1$ and a full disagreement $S=0$.

One method of cluster analysis elaborated by Sokal and Sneath / SOKAL, SNEATH 1963 / was transferred for computer treatment by Bonham-Carter / BONHAM-CARTER 1967/ "Fortran IV program for Q-mode cluster analysis of nonquantitative data using IBM 7090/7094 computers". It is a Q-mode analysis in which the samples are grouped into clusters. A reverse type of analysis is a R-mode where the character data are clustered / SATTRAN 1979/. The classification of qualitatively expressed characters is difficult, however, by the R-mode analysis.

Sokal-Sneath method is called as pair-group method because only one pair of samples can create a group in the same iteration cycle. The pair is formed in such a way that are chosen the samples in which the greatest similarity coefficient is common for both. For the next cycle, each formed pair is considered as a unit with an averaged similarity coefficient. The procedure is repeated until a cluster is formed of all samples analysed. An average, we may set up either by a weighing-method where all groups have the same weight irrespective of the number of samples or by non-weighing-method where each sample has the same weight. Results of classification can be expressed graphically as so called dendrograms or dendrographs. The dendrogram is an one-dimensional graph in which the ordinates are the values of similarity levels around which the grouping occurs and along x-axis are the samples arranged in the order of clustering. The dendrograph is a two-dimensional graph in which the ordinates are the values of similarity levels around which the grouping occurs and along x-axis are the samples or groups more concentrated or more diluted in dependence on their similarity or dissimilarity. MEV - mean expected value indicates the similarity level around which clustering would be expected to take place if the same number of positive and negative matches were randomly arranged.

Input data

A matrix of qualitative data which is used for the treatment on computer is formed in the way that attribute which is present is denoted by the number 2, property which is absent by the number 1 and in the case of no information the number 0 (zero) is used. For semiquantitative data, we can employ a multi-step scale, eg. 222 great quantity, 221 medium quantity, 211 low quantity, 111 quantity absent.

As an example, the computer treatment of data obtained from emission spectral analysis of samples of pottery found in mastaba of Princess Khekeretnebtay (Scientific Expedition of the Charles University Insti-

tute of Egyptology to Egypt in 1976) has been used. The example indicates the advantage of the use of cluster analyses for classification of archaeological objects. The result has completed the grouping derived from the archaeological point of view and enabled to revise the problem. It might contribute to more objective conclusions. Physico-chemical methods of analysis connected with computer technique became an excellent aid in the scientific treatment of objects from museum collections. Input data are given in Tab.I, calculation algorithmus in Tab.II and a graphical representation of results expressed as a dendrogram in Fig.1. We may expect that close to the level of MEV are formed groups of similarity which possess real common properties characteristic for each group of samples.

We mentioned already the use of this method in our paper read and published at the 5th ICOM Committee for Conservation Triennial Meeting in Zagreb in 1978 for the classification of pottery from Nubian Cemeteries from the 4.-6. century A.D. /ČEJKA et al. 1978/. Cemeteries studied were evaluated from the archaeological point of view by E. Strouhal and conclusions were modified on the basis of results obtained by cluster analysis (2nd Egyptological Congress at Grenoble in 1979) /STROUHAL et al. 1979/. The detailed results of the study on the cemeteries Wadi Qitna and Kalabsha-South will be published later /STROUHAL et al., in press/.

S u m m a r y

In the paper we point out on the application of numeral methods as cluster analysis for the examination of archaeological, museum and further materials and objects which are described by a lot of experimental non-quantitative data which are necessary to be classified in order to find groups of objects with similar properties.

This relatively simple method has become employed not only in the museum chemistry for the study of glasses, ceramics (pottery), metals, pigments etc., but even in the classification of the mentioned objects for the reason to choose relevant procedures of conservation or restoration of them. In all cases, we must deal with large set of objects described by many variables.

The analytical methods of all kinds show enhancing trend of application in the museum chemistry and conservation. Therefore we consider a simultaneous extension of the methods of cluster analyses also in the field of the treatment of museum collections.

Table 1
Input data

Sample No	As tr.	O.O.X%	Li tr.	O.O.X%	Ni tr.	O.O.X%	O.X%
E 113	2	2	2	2	2	2	1
114	2	2	2	2	2	2	1
115	2	1	2	1	2	2	1
116	2	2	2	1	2	1	1
117	2	2	1	1	2	1	1
118	2	1	1	1	2	2	1
119	2	1	2	2	2	1	1
120	2	2	1	1	2	2	1
121	2	1	2	2	2	1	1
122	2	2	2	2	2	2	1
.							
.							
.							
167	2	1	2	2	2	2	1
168	2	2	2	1	2	2	1
169	2	1	2	1	2	2	1
170	2	2	2	1	2	2	1
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Concentrations of 30 elements have been determined in the range 0 - XO.0% on an emission spectrograph Q 24 Zeiss. The obtained data were treated on the computer EC 1040.

Tab. II

Calculation algorithmus

CLUST-3

MAIN : Input instruction for calculation
 Input data
 Check for redundant characters
 Consolidate data matrix
 Calculate mean expected value of association
 Clustering
 Call alternately subroutines LARGE and RECALC untill all samples have been grouped together

 LARGE : Select those pairs of samples (groups of samples) with the highest coefficient of association for linkage in a particular cluster cycle
 Write paired sample numbers, level of association and cycle number

 RECALC: Calculate new values of association between all combinations of paired and unpaired samples (groups) using arithmetic averages
 For the unweighted method, calculate the size of each group

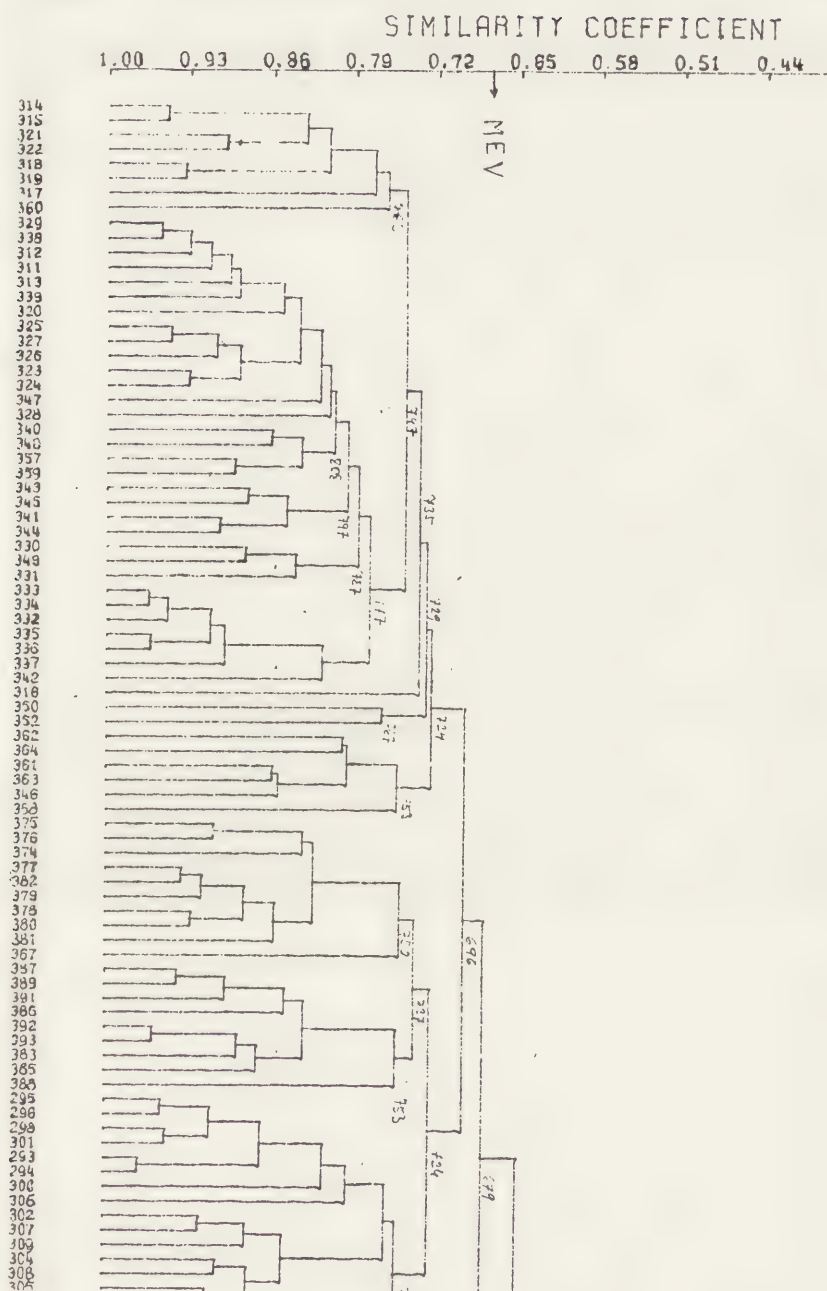
 ORDER : Put samples in dendrogram order

 DENDRO: Calculate x-y coordinates of points to be linked for forming a dendrogram
 Punch coordinates on cards

DNPLOT: Use the punched output from DENDRO as input, and control the sequence of plotting instructions to CALCOMP digital plotter

Note: The plotting routine DNPLOT has been separated from the main program CLUST-3

Fig. 1 Dendrogram



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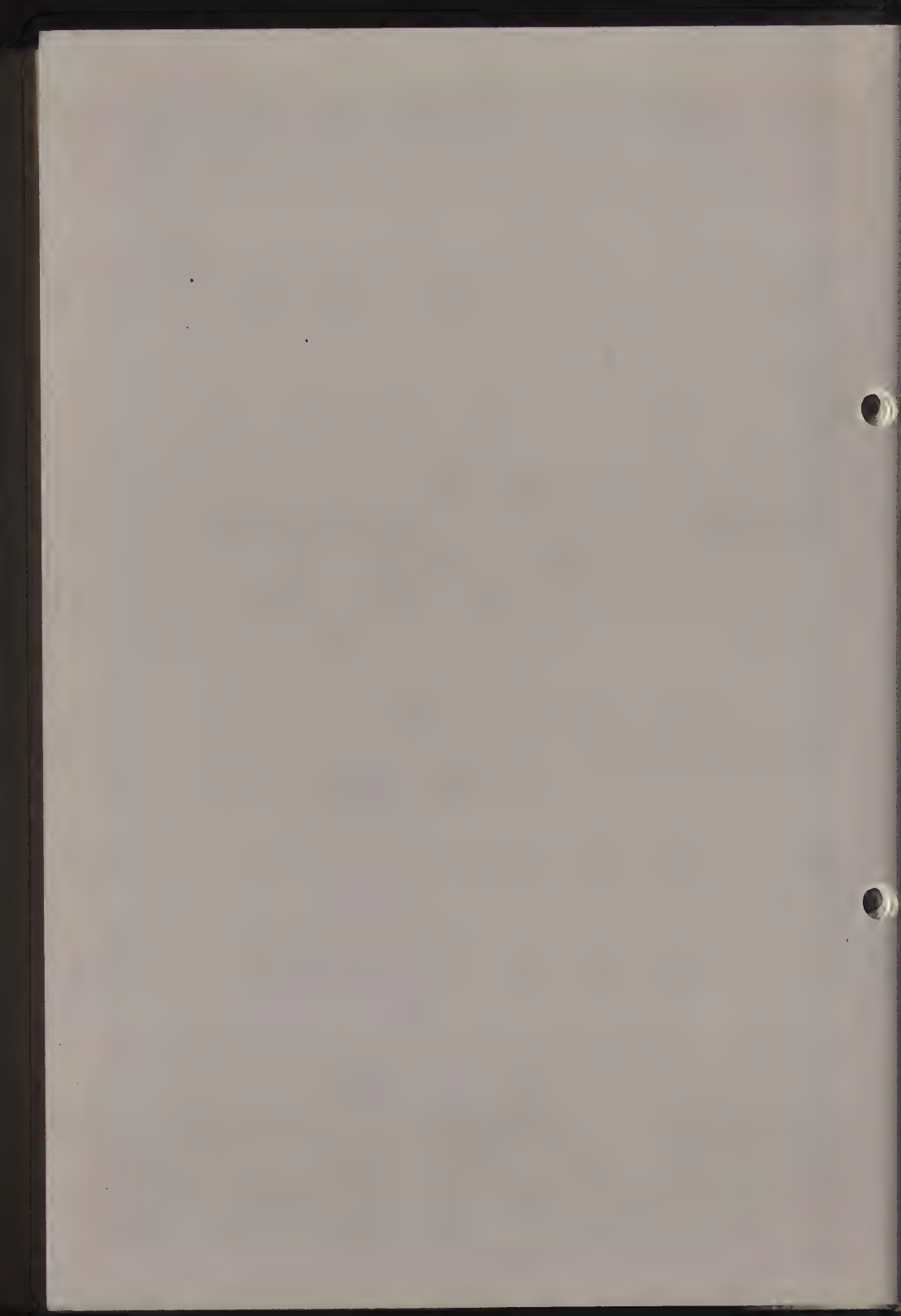
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NONDESTRUCTIVE SAMPLING ON OBJECTS OF
GRAPHIC ART FOR X-RAY MICROANALYSIS

F. Mairinger, G. Banik, W. Koehler and
H. Stachelberger

ICOM Committee for Conservation
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ABSTRACT

A nondestructive sampling method for single grains of pigments applied in colour etchings for quantitative x-ray microanalysis in connection with a scanning electron microscope (SEM) is described. A copper support grid, usually used in transmission electron microscopy, is cemented on a polished block of resin and forms a quadratic screen. This block is pressed on the painted area. Single pigment particles adhere on the surface of the plastics. The copper grid allows retrieval of definite particles by comparison of the light microscopic and the electron microscopic image. It serves also as a pure element standard for quantitative analysis of copper pigments. Examples of the application of the method and analytical data are given.

1. INTRODUCTION

In the course of the investigation of the destructive properties of green copper pigments (1) on cellulose a quantitative analysis of the used pigments was necessary. The object under investigation was an illuminated book on costumes printed in 1578, where large areas of the different greens showed all stages of discolouration and destruction. Since the available amount of samples was very small, the quantitative analysis of the pigment used was done by energy dispersive x-ray analysis. The instrument used, was a transmission electron microscope JEOL 100 C with a scanning attachment and an energy dispersive spectrometer, LINK, EDX 290 (EDS). Although the sensitivity of this method is very high - a few grains of the colouring matter are sufficient - the sampling method and

the identification of a selected grain in view of the the extremely thin paint layers present many intricate problems. A well known method, which was also used in our previous investigations (1,2) makes use of an adhesive tape, which is applied cautiously under slight pressure on the area under investigation. By taking off the tape carefully a few grains stay embedded in the adhesive layer. After an inspection under the stereo microscope, the tape is attached to a sample holder and coating it with carbon or gold/palladium it can be viewed and analyzed under the electron microscope without any further preparation. In spite of its obvious simplicity this procedure has several severe drawbacks affecting the performance of the analysis: It is practically impossible to analyze particles smaller than 5 μm , since they sink into the soft adhesive layer and grains even larger in size get covered in an unfavorable way with this adhesive. The latter also contains volatile components spoiling the vacuum and giving rise to migration of the particles during analysis. Erroneous results of the quantitative analysis can be the consequence. Furthermore nearly all tested tapes show an appreciable amount of chlorine. A disadvantage of the electron microscope in analyzing pigments lies in the fact that the colour of the different particles is not rendered, a valuable feature for the experienced investigator in the analysis of complicated mixtures of pigments by light microscopy. To overcome these difficulties a new and simple method of sampling and relocation of particles was to be developed and will be described here.

2. EXPERIMENTAL

On a small polished block of epoxy resin a fine copper support grid (200 mesh), as it is used quite often in transmission electron microscopy, is cemented by means of UHU-Stic (polyvinyl resin). By short polishing the excess of cement is removed and the copper grid lies blank on the surface afterwards. The object under investigation is placed on a hard, even support (e.g. glass plate). By pressing the polished resin block on the chosen area, a sufficient number of pigment particles sticks to the surface by adhesion forces without need for an adhesive layer. These forces are strong enough to prevent a migration or dislocation of the particles, even when during the analytical procedure small vibrations occur. This method is especially suited for grain sizes below 2,5 μm . In the case of particles larger than 3 μm the electron beam causes electrostatic charge phenomena during the analysis which counteract the adhesive forces and catapult grains off the support. Since such large grains were not present in the samples, the "impress method" was quite satisfactory for specimen

preparation. The block loaded with the sample was viewed under the light microscope and colour slides of the interesting areas were taken. The copper grid provided a coordinate system - the center of these grids is marked by an arrow - by which it was easy to retrieve a selected particle on the image screen of the electron microscope. The colour rendition could be obtained by projecting the colour slide simultaneously for comparison. A further benefit of this method is the fact that the copper grid serves also as an element standard for the quantitative analysis of the occurring copper compounds. Furthermore this sampling method leaves absolutely no visible traces or destructions on the object.

3. ANALYTICAL RESULTS

The investigated samples were taken from 2 pages of the illuminated book cited above:

BRUYN, Abraham de,: Imperii ac sacerdotii ornatus
Diversarum item gentium peculiaris vestitus.
Adiunxit commentariolos Caesarum, Pontificum ac
Sacerdotum Hadrianus Damman, Coloniae 1578
(Österreichische Nationalbibliothek, Theatersammlung,
622.191-C Rara)

Page 31 showed no visible discolourations or deteriorations within the green areas, this holds even to the reverse side.

Page 53 exhibits damages to a medium extent, the paper under the green parts is slightly embrowned and already perforated.

Quantitative analysis of the colouring matter by EDS is rather difficult if the pigment particles are very small and the microgeometry is unknown. In the following cases a quantitative determination with the aid of the ZAF method (correction functions based on average atomic number, x-ray absorption, and interelement fluorescent effects) was possible, because the particles under examination fulfilled the bulk condition quite well. So the green paint layer of page 31, which was exceptionally well preserved and was already examined by IR-spectroscopy indicating the presence of malachite, was also analyzed by EDS. The quantitative evaluation gave for the green particles a copper content of 58,3 to 60,8 %, values corresponding well to that of mineralic malachite (57,5 %) which served as a standard. The light microscope revealed in these samples also the presence of white particles in appreciable amounts. They contained as main components magnesium and calcium. Silicon was absent in the x-ray

spectrum. Therefore it had to be assumed that dolomite the isomorphic mixture of calcium and magnesium carbonate was present. This assumption is substantiated by comparison of the observed intensities of the K-lines of these elements with those of a standard sample of dolomite.

The excellent preservation of the green areas of page 31 can be attributed to this admixture of dolomite or a similar compound of calcium and magnesium to the malachite, since in all other destructed green areas of the object these two elements are missing or present only at very small concentrations. This fact supports the conjecture that the alkaline earth-ions, especially magnesium, inhibit the catalytic action of copper ions in the degradation of cellulose.

The most interesting result was obtained with samples of page 53, where the green pigment had caused already a visible decay of the paper carrier. The evaluation of the quantitative analysis brought an average copper content of 55 % and a surprisingly high chlorine concentration of 15 - 16 % (compare Table 4 and Figures 1 and 2).

Compared with other samples taken from different pages the chlorine values were higher and differed by a factor of 25 to 30 in this case. Important seems also the fact that in the x-ray spectrum of this chlorine containing sample the K-lines of the alkaline metals (Na, K) could not be detected. Supposing the absence of lithium, which seems to be a rather sensible assumption, the conclusion must be that chlorine is bound to copper. The percentages of copper and chlorine obtained after ZAF correction do not allow the definite identification of the compound, but it must be one of the many existing basic copper chlorides, besides the well known atacamite and para-atacamite ($\text{Cu}_2\text{Cl}(\text{OH})_3$, 59,5 % Cu; 16,7 % Cl). The lower copper and chlorine concentrations calculated from the count rates could be explained in the way that the condition of bulk samples was not quite fulfilled to the necessary extent. Tables 1 to 4 show the obtained analytical data of the samples taken from page 53.

All analytical results were obtained with the following instrumental data:

Accelerating voltage: 40 kV
 Specimen tilt: 40°
 Time of analysis: 50 sec.
 Take-off-angle: unknown due to irregular shape of particles
 Coating: 250 Å carbon

Table 1: Semiquantitative analysis of some selected pigment particles taken from page 53

Analysis	Al K	Si K	net counts		K Ka	Fe Ka	Cu Ka
			S K	Cl K			
1	----	230	700	7760	100	260	37850
2	90	130	480	630	320	---	17800
3	120	210	320	430	150	120	21980
4	----	---	380	1120	830	260	14320
5	210	360	120	840	770	---	9830
6	80	---	440	950	480	320	10950

X-ray intensity of pure copper standard: 115200 counts

Table 2: Analysis of an unpainted paper sample

Analysis	S K	Cl K	net counts		Ca Ka
			K Ka		
1	850	----	230		630
2	590	110	420		380
3	760	90	240		580

Table 3: Quantitative analysis

Analysis	S K	Cl K	net counts		Cu Ka
			K Ka		
1	530	13620	210		62500
2	450	13720	90		60950

X-ray intensity of pure copper standard: 115200 counts

X-ray intensity of chlorine standard (NaCl): 71500 counts

For quantitative evaluation it was assumed that copper is embedded in a matrix of chlorine and oxygen.

Table 4: Concentration of Cu and Cl (weight-%)

Analysis	Cl	Cu
1	15,13	55,22
2	15,78	56,05

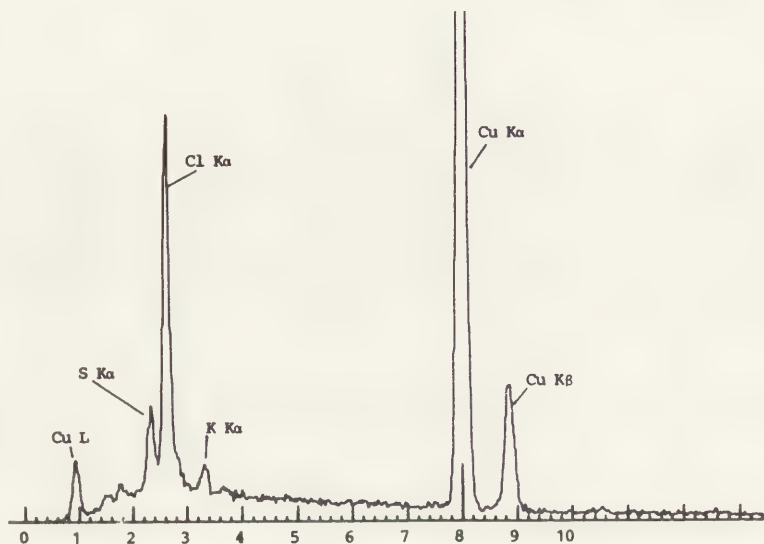


Fig. 1 X-ray spectrum of analysis 1

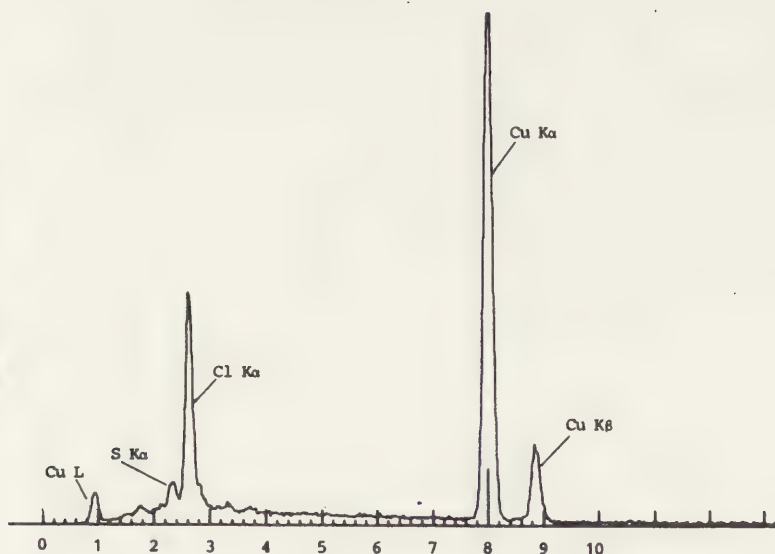


Fig. 2 X-ray spectrum of analysis 2
(intensity axis smaller than in figure 1)

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Acknowledgement

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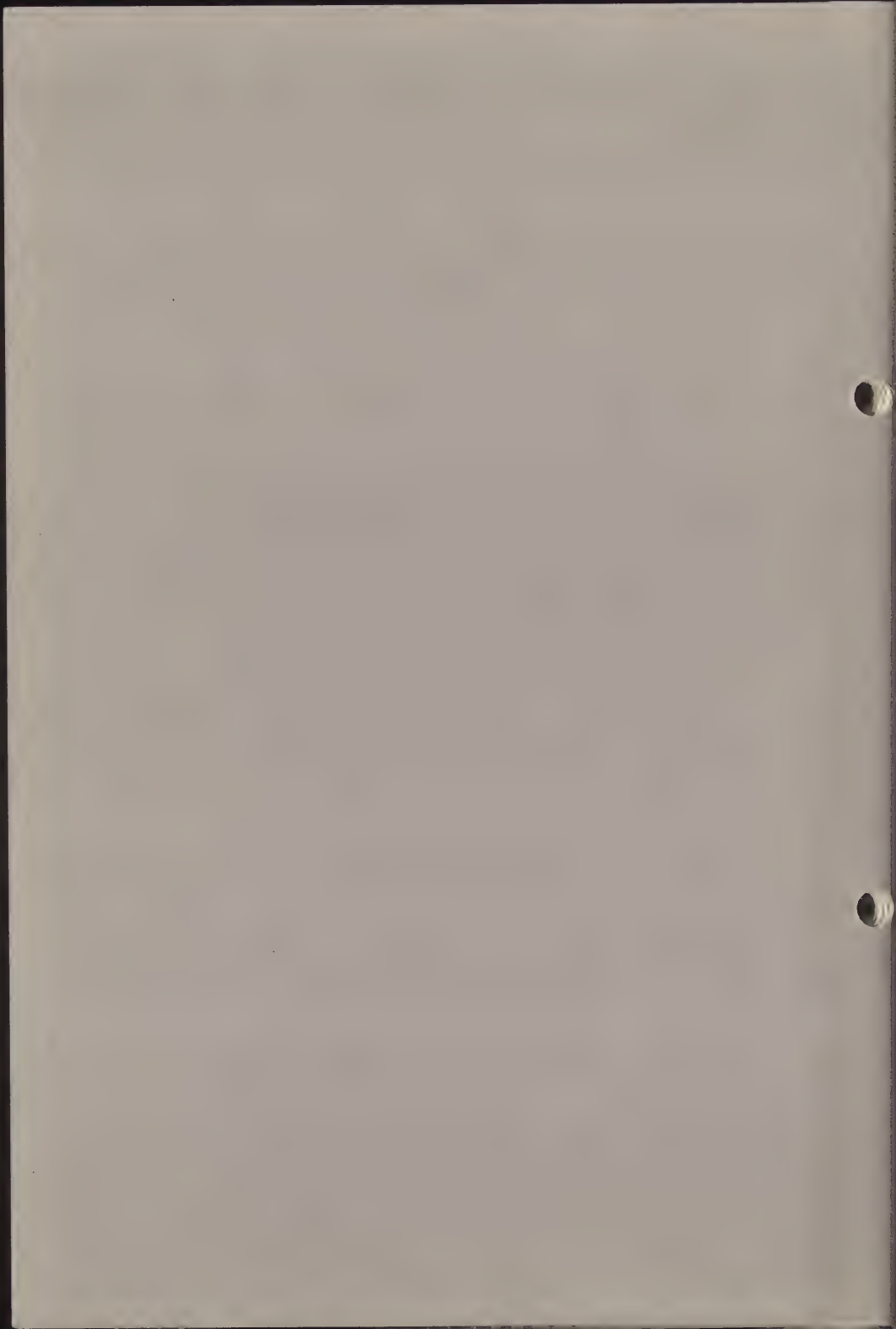
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TOPOCHEMICAL REACTIONS FOR THE RECOGNITION
OF OIL MEDIA IN PAINT FRAGMENTS

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Abstract

Among the analytical approaches for identifying binding media used in painting, particular importance is given to topochemical procedures that permit the contemporary identification and location of a particular class of materials in the cross-section of a representative fragment. Having established that the staining methods at present available for identifying oily media almost always give uncertain or negative results when applied to sections of old painting fragments, the authors suggest a new analytical procedure based on the recognition of an intermediary amine preventively fixed to the oil medium present in the sectioned fragment.

The importance of topochemical analyses

The study of the composition of a representative fragment taken from a work of art, or, in other words, the identification of the component substances, can be carried out following two main analytical directives.

A type of procedure makes use of highly sophisticated microanalytical techniques for attempting to identify the substance in the bulk of others without taking into consideration the position it actually occupies in the sample structure.

A different kind of approach by means of suitable detection reactions carried out on a section of the fragment, arrives at visual identification of a particular class of substances in the actual position they occupy.

In the latter case the sample remains structurally complete

during the analytical process except for its dissection; as the cut however is perpendicular to the layers, the section keeps its original compositive structure intact. The latter procedure is typical of that used in histochemistry but, as the object of identification does not consist of a tissue, we could more correctly refer to it as "topochemistry".

The topochemical reactions therefore allow identification and, at the same time, the localization of a substance in the bulk of a sample. This possibility is a very important fact, as the constitutive structure of many works of art is of a stratigraphic type as well as many surface transformations which are brought about on the painting by time (ageing, degradation) and by man (restoration).

When topochemistry, like histochemistry, is applied to scientific investigation of works of art (at present only in its early stages) it does not usually provide results of high analytical precision (in a qualitative sense) compared to those obtainable by the above mentioned methods.

Often a class of substances rather than a single substance is identified.

On the other hand, what topochemistry does not possess in qualitative precision, it gains in accuracy of positioning. Moreover, to a practised eye, it can also supply semi-quantitative valuation for comparison.

Finally, the best way of carrying out this kind of analytical investigation is therefore by integrating the two procedures with one another.

Topochemical reactions in the analysis of binding media

It is well known that sensitive methods for identifying proteinaceous materials in paint fragments are already available. (1-9).

Using these methods, egg, casein and above all animal glue media can be identified and located with notable precision in the cross-section of a paint fragment. These methods mainly consist in making the material which is to be identified absorb a particular dye in an irreversible way (fixing). Its position is then easily microscopically recognizable through the colour.

The staining operation must be resistant to a particular washing process (necessary for the elimination of unfixed dye). It must moreover selectively interest only a particular substance or class of substances.

A simple procedure is used (fig.1).

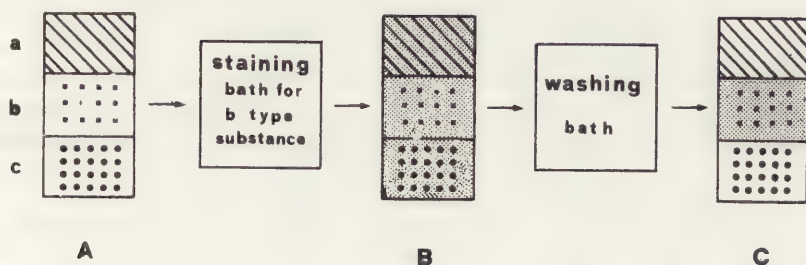


Fig.1 - Staining procedure

A - Untreated sample

B - Absorbed and fixed dye

C - fixed dye

The second bath washes off all the excess dye retained in the structural porosity of the sample, while leaving that firmly "fixed" by chemical bonds or physical interactions.

The majority of acid dyes used for the staining of proteinaceous materials are probably fixed with acid/base type mechanisms which involve reactions with the basic groups in the protein.

At present the processes available give very satisfying results in the topochemical analysis of animal glues and, to a minor degree of egg and casein. It is not possible however to identify with certainty each of these three important proteinaceous binding media.

Another typical sensitive and selective topochemical reaction is that for the identification of starches and other starchy substances (dextrin etc.) which employs an aqueous solution of Iodine (Lugol).

The purple-black staining obtained in the presence of starch is sharp and selective.

On the contrary the topochemical reactions at present available for the identification of fatty substances, especially of drying oils, are much less reliable.

The presence of a drying oil in a painting (often so obvious in the practice of restoration, even if this does not always correspond to the actual situation) is not easily confirmed by scientific analysis, especially if

its identification is not only requested, but also its localization in the context of a painting.

It is well known how the identification of binding media can be very helpful to many studies in the conservation field, to the understanding of a painting's technique and to the recognition of false paintings.

Linseed oil and a few other drying oils, either alone or mixed, can be found in any one of the paint layers, as well as in the ground layers, in the primings and in the surface coatings.

Its identification in the actual position which it occupies can constitute a significant element for the study of painting.

Dyes now available for the topochemical identification of oils (2, 3, 4, 9, 12, 13, 14) generally stain them by physico-chemical affinity. In this specific case, as the substratum is made up by an oil, i.e. by a lipidic substance, the dyes used have a lypophilic nature. They probably dissolve in the oil as they are similar to it.

While samples of recent ageing (reference samples artificially prepared and naturally aged for a few years) show a very good staining ability, results are only partially or completely negative in the case of samples taken from old oil paintings.

It is well known that the drying process of oil media (although not yet completely clarified) consists essentially in a double reaction: a spontaneous oxidation of unsaturated glycerides occurs at first, followed by a probable setting up of peroxidic bonds.

The break down of these groups would then cause a slow second process of polymerisation.

Finally a cross-linked polymer (linoxyn) is obtained which is autoplasticated by the liquid unoxidized glycerides dispersed in the polymer.

The conservation procedures (lixiviating cleanings), the slow processing of oxidizing reaction and finally various degradation reactions, are factors which may contribute to the progressive depauperation of liquid or semifluid glycerides in old samples.

Thus, while recent samples, which still contain liquid glycerides, would maintain a good receptivity to staining, the very old ones, as confirmed by experimental tests, would become progressively inert. As a consequence of this fact the staining method "by affinity" only gives negative or uncertain results in most of the cases.

Different new mechanisms of identification must then be

found for the topochemical recognition of oils.

Identification of oils by recognition of intermediate amines

The suggested procedure here, completely utilizes different criteria and, although still in an experimental stage, has given encouraging results with a generally good reproducibility and sensibility.

In a previous study carried out by the authors on the solvent retention which occurs during cleaning operations of paintings, it was noted that some organic solvents containing basic nitrogen atoms, were firmly retained by the oily medium of pictorial film for quite long periods (over a month).

The behaviour of some amines such as n-butylamine, morpholine and also pyridine, was noted.

The very high retention times together with strong alkalinity values of this kind of liquids confirmed the absolute inadequacy of them as solvents for picture cleaning.

More recently n-butylamine has been used in our laboratory as an extractive solvent for the "dissolution" of polymerized oils and other fatty substances from paint samples. Extracts are then analysed by instrumental methods.

The I.R. absorption spectra of the residue obtained from n-butylamine oil extracts, (also dried for several minutes at 80°C) showed up new absorption bands different from those typical of the oils, one in particular located at about 1550 cm^{-1} . The latter at least proves that n-butylamine fixes well on the oil components used in painting. The precise mechanism causing n-butylamine to interact with drying oil molecules and the actual kind of bonds formed are at present still being investigated.

The reaction causes a partial dissolution of the oil or rather a formation of some liquid phases. This constitutes a serious limit to topochemical reactions because of possible transfer of material from the original positions. However, when working in experimental conditions with a minimum formation of liquid phases, n-butylamine can be used as a suitable intermediary reagent for the location and identification of oils.

Nevertheless, as the used amine is a colourless and non fluorescent substance it is unsuitable for a direct microscopical detection. It is then necessary to use a further chromatic reaction, for the recognition of the amine.

The best operating conditions were found by utilizing vapour rather than liquid butylamine thus avoiding transfer of materials.

A cross-section of the sample is kept for a certain time at room temperature in a reaction tank saturated with n-butylamine vapour (b.p. 77.8°C). The reaction time was critical (fig.2): while the reaction yield (and therefore the sensitivity) increases with reaction time, a progressive destruction of the original sample structure, as a consequence of liquid phases formation, occurs.

As the latter phenomenon has a slow initial rate followed by a sudden increase (collapse of structure) it is advisable to stop the reaction before structural destruction takes place. Accordingly the reaction must be carefully followed under a stereo microscope.

As a reaction room (fig.3), a glass tank with a thin, flat and airtight glass lid can be used.

The cross-section rests on a small glass cylindrical base suitable for easy observation. Liquid n-butylamine is placed on the bottom of the tank.



Fig.2

- a) reaction yield
- b) structural destruction
- t) optimal reaction time

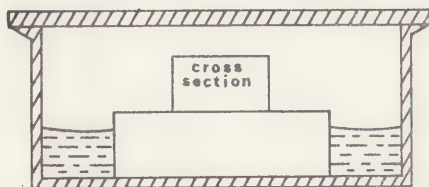


Fig.3 - Reaction Tank

Once the amine is fixed it is necessary to eliminate the excess reagent absorbed, only retained by physical forces. In histochemistry this step usually corresponds to the "washing" operation.

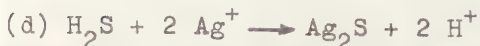
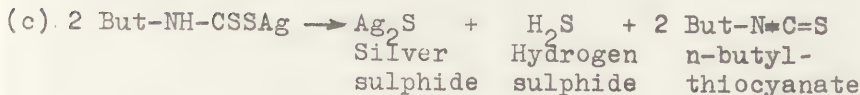
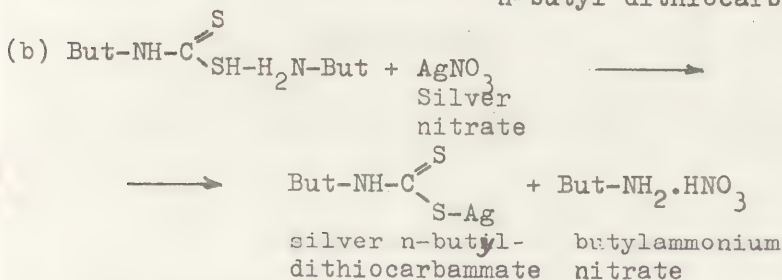
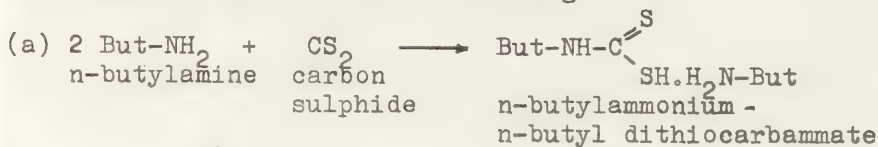
It is preferable to eliminate the excess highly volatile amine by vaporization instead of washing out it with a solvent. This is carried out by warming in an oven.

Experimental tests indicated a vaporization time of about 15 minutes at a security temperature of 80°C.

Finally, the last operation requires chromatic reactions; this must be carried out on the surface of a cross-section without altering its structure. Accordingly the chromatic reactions must submit to very restricted conditions: liquid reaction products must be avoided (danger of transfer of materials); drastic reactions (acids, bases, very high temperatures, excessive reaction time, development of gas, etc.) that would destroy the structure of the sample cannot be used; finally possible interferences must be limited as much as possible.

A suitable sequence of reactions was found in the following microanalytical procedure for the recognition of primary and secondary amine (10, 11).

The reactions could be the following:



The first reaction product (the amine thiocarbammate) is a solid, slightly yellow, transparent substance. It is rapidly formed even at room temperatures. Decomposition,

with the formation of black Silver sulphide takes place when ionic Silver is present.

The formation of sulphide takes place within a few minutes (from 4 to 10 at room temperature) when a concentrated aqueous solution of Silver nitrate is used.

The first reaction (a) is carried out using Carbon sulphide vapours, placing the cross-section in a reaction tank identical to that previously used. In this way the unpleasant smell of this compound can be avoided.

As seen by experimental controls the best time for this reaction was about 5 minutes (s.t.p.).

Excess CS_2 is then eliminated by means of cold ventilation. Using a stereo microscope a drop of Silver nitrate solution is then carefully applied with a glass micro-rod onto only a half of the surface of the sectioned fragment. In such a way the evolution of the chromatic reaction is more easily controlled by comparison. A drop of concentrated nitric acid whose vapours are absorbed by the drop of $AgNO_3$ solution, is also placed on the surface of the section³ but not on the fragment. It helps the decomposition process.

When oil is present a progressive formation of Silver sulphide can be seen after a few minutes: first brownish-yellow in colour, then brown and finally black. (see scheme fig.4)



Fig.4 - Topochemical recognition (black and dashed) of fat substances, on a half part of cross-section.

- a: gesso + glue ground
- b: White Lead + egg priming
- c: oil paint layer
- d: resinous varnish layer

Conclusion

Analytical procedure is composed as follows:

- 1 - anchorage of vapour n-butylamine to the drying oil in the sectioned sample (av. time 5 minutes).

- 2 - elimination by heat (80°C) of amine not fixed to the oil (15 minutes).
- 3 - formation of amine dithiocarbamate by reaction with vapour Carbon sulphide (5 minutes).
- 4 - elimination of excess Carbon sulphide by cold ventilation (av. time 2-3 minutes).
- 5 - chromatic detection with Silver nitrate concentrated solution (maximum 10 minutes).

After reaction, the cross-section is washed with distilled water, taking care to avoid transfer of materials, and then observed under an optical microscope.

The whole operation takes less than 45 minutes.

Experiments were carried out on sections of numerous fragments of painting samples, some artificially prepared but most from old paintings of different periods and pictorial techniques.

One must emphasize the difficulties which are usually found in identifying old artistic materials. The only really valid experimentation of analytical procedures is that carried out directly on original old samples. Unfortunately the materials which are now available widely differ from corresponding aged substances radically transformed by natural processes or man's intervention.

However, old pure reference materials do not exist nor is it possible to know them. Therefore compromise is necessary. In any case we believe that controls carried out on old reference materials whose composition may be supposed, are the most reliable.

This criterion has been closely followed when controlling the analytical procedure for oils identification given here. The fragment included in polyester resin Synolite 328/64/4006 by Synres Sp. A and sectioned, is first tested for proteinaceous materials using the staining procedure with Amido Black (5-9). A microphotographic documentation is then made. A second grinding of the cross-section to obtain a new intact section surface, follows (the grinding liquid is White Spirits).

The proposed topochemical procedure for oils identification is then carried out and results are noted.

A comparison is then made with previous results (reaction with Amido Black) for analytical interpretation.

A clearly positive test in the paint layer was obtained for most of the samples with a probable oil medium.

We also had positive tests for ground layers supposedly containing oil.

Ground layers containing proteinaceous materials (animal glues) gave negative results for oil in some cases while

in others gave partially positive ones. The latter cases were interpreted as protein - oil mixtures (animal glue + oil).

The same topochemical procedure was carried out on sections of paint fragments from old tempera paintings presumably with an egg medium.

When a partially positive protein test occurred in the paint layer, we followed this with a topochemical control for fatty substances.

In this case as well a partially positive result was obtained; the staining resulted as a brown colour instead of becoming black as it would be in the case of oil. This was probably due to a lesser amount of fats contained in egg as compared to oil.

Similar results ^{were} also obtained in recently prepared samples with egg tempera medium.

Varnish layers of presumably resinous composition usually gave negative results.

Parallel staining tests carried out on recent reference samples of mastic dammar and beeswax also gave negative results.

Interference was noticed from pigments made up of decomposable sulphides like Cadmium Yellow or Cadmium Red (CdS and CdS, Se) and also Lapis-lazuli and artificial Ultramarine.

In fact the decomposable sulphides, together with Silver nitrate, directly form black Silver sulphide; however these cases are easily verifiable beforehand.

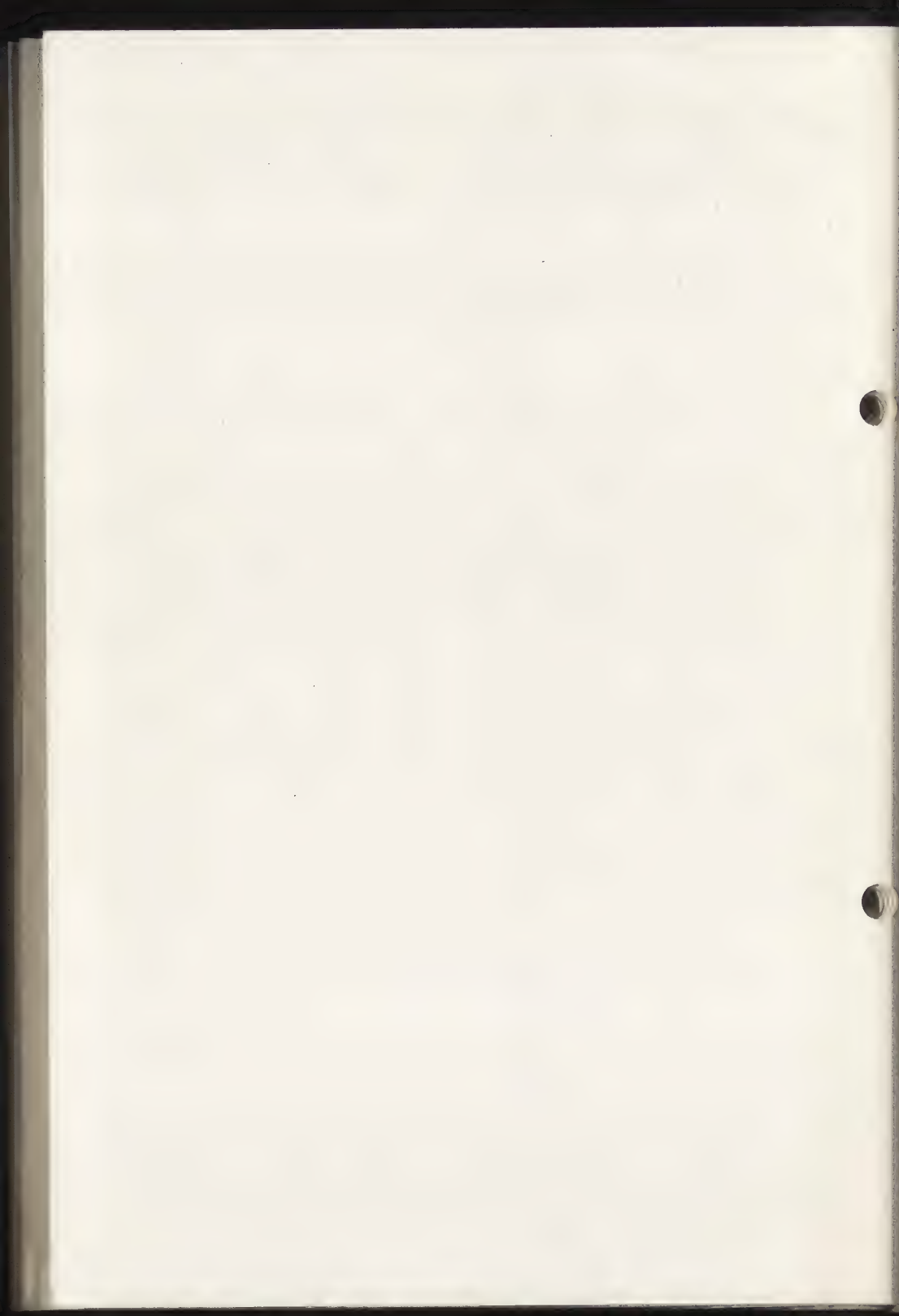
In conclusion we can affirm that during this preliminary investigation the method described for the topochemical identification of oily substances in cross-sections of paint samples may be considered sufficiently sensitive, reproduceable and selective to warrant further extensive experimentation and verification.

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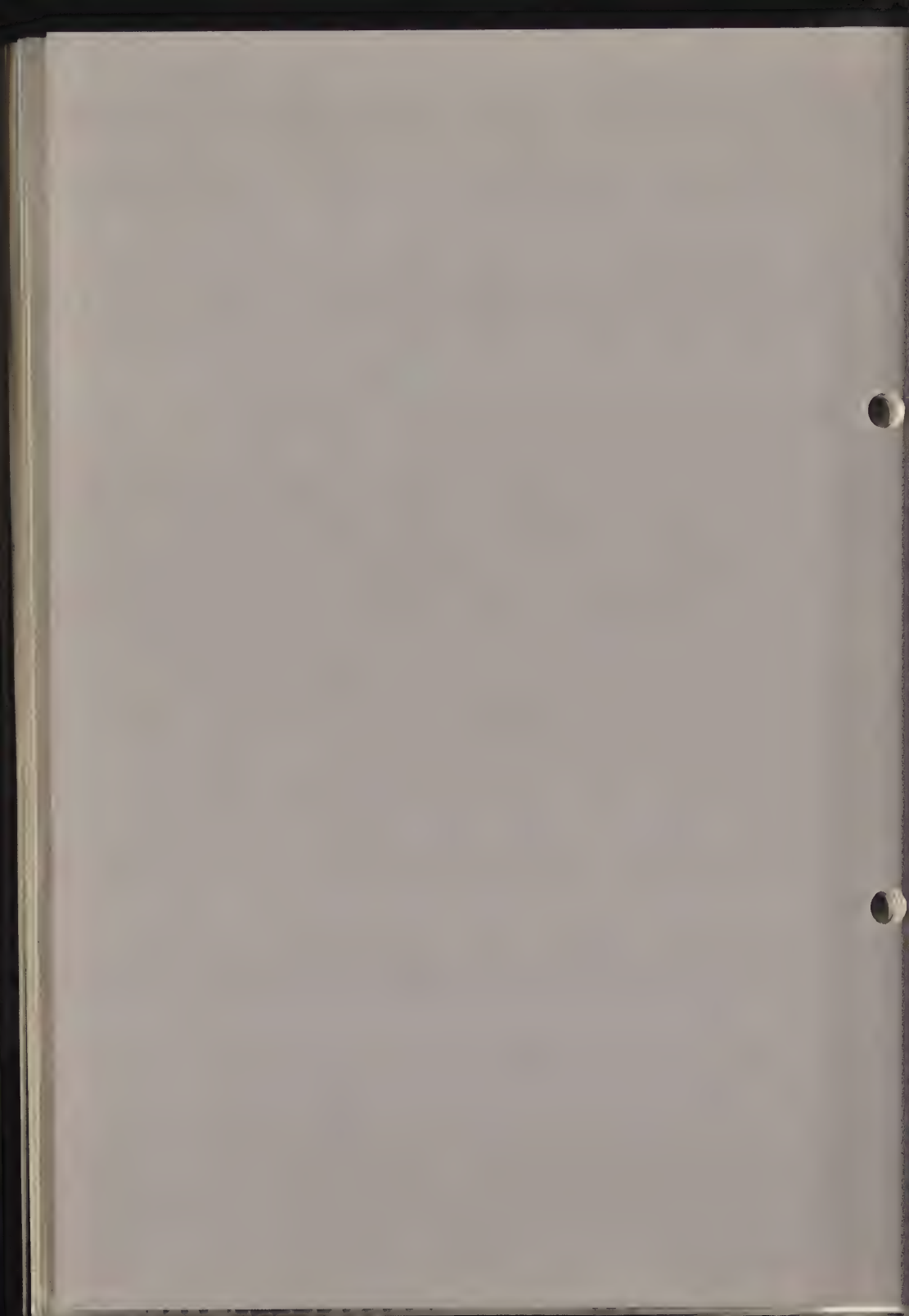
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X-RAY ANALYSIS OF A SUPPORT WAX ("THIN")
CANDLE DATED LATE 17TH CENTURY

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Chepurnoi

ICOM Committee for Conservation
6th Triennial Meeting
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Working Group: New Applications of Methods
of Examination



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Examined are the conditions and results of an X-ray analysis of a volumetric exhibit -- a support wax ("thin") candle shaped like a hollow cylinder and ornamented with coloured waxes in wax intarsia technique. The analysis was made with the help of the REIS portable X-ray unit. Comparison of the X-ray analysis data and of data obtained by physico-chemical analysis of colouring agents is given. An attempt was made at establishing the manufacture technique. Restoration methodology is described.

The REIS medical X-ray radiator with microfocal BS-1 tube has been used in the Department for the Analysis and Restoration of Painting of the Special Restoration and Designing Institute for the study of paintings and works of applied art since the beginning of 1977.

REIS has been found suitable for the purpose because

-- it makes possible to obtain contact photographs as well as roentgenograms with up to 15 X magnification without any substantial geometric blur. The latter is unavoidable when other X-ray units are used;

-- it is compact and light (12 kg), has insignificant free radiation and low electric power consumption. Hence the premises (museums and restoration shops) in which the radiator is used need no special preliminary outfitting.

One of the latest experiments with the REIS was an X-ray analysis of a support wax ("thin") candle.

The support wax candle is a hollow wax cylinder (hence the name "thin") about one metre high and about 30 cm in diameter. Such candles were made in Russia in the 16th-17th centuries of wax or, more often, of wood. Shaped like a hollow or monolith cylinder, they had a richly ornamented surface and were used in

churches and ceremonial chambers as lampions. Fixed on the top of the candle was a round metal plateau, also richly ornamented, with sockets for a bigger candle in the centre and for smaller ones around it. A lampion of this kind was mounted on a stone, metal or wood stand similar to a column socle. Support candles were rarely made of wax, for their manufacture was a lengthy and labour-consuming process. The best-known and best-preserved wax support candles adorn the interiors of the Basil the Blessed Cathedral in Moscow's Red Square and the Church of the Twelve Apostles in the Moscow Kremlin.

The "thin" candle sent to our department for analysis and restoration was 108 cm high, 28 cm in diameter at the top and 31 cm at the bottom. Its walls were 4-6 cm thick. No information about the method of its manufacture was available either in written documents or in oral folklore. It was decided to make an X-ray analysis, to take samples for chemical analysis in order to determine the composition of the wax and of the colouring agents of the ornamental design and establish, if possible, the original technological process.

The exhibit was badly damaged. A 30x27 cm fragment was broken off from the top of the cylinder, and the ornament-free upper edge of the fragment 8x30 cm

in size was missing. The ornamented belt in the lower part of the candle was also virtually missing.

At the detachment edge of the candle and fragment the wax was flaking off. There were several deep cracks on the inner and outer surface of the cylinder. On the inner surface there were also streaks of wax and gypsum used earlier to fix the fragment and prevent the wax from flaking off. Spots of scale destruction of various size were also present. The plant design originally done in white, red and blue waxes was completely painted over with oil paint. The outer surface of the cylinder was damaged by dents and abrasions, in some places coloured wax was missing. The ornament was soiled by dust and soot.

Physico-chemical analysis and subsequent X-ray-ing with the help of the REIS radiator made it possible to establish the composition of the materials used.

The film was put in a dark paper envelope and firmly attached to the inner wall of the cylinder. A test photo was taken to choose the exposure. The working conditions under which the photographs were taken were 25-kv voltage, 60-ma current and 80-second exposure. (See Chart 1.)

The contours of the ornamental design with admixture of white lead are clearly visible on the photographs -- they are white. The rest of the orna-

ment, where other colouring agents were added, is of a darker hue. Cracks which look like dark broken lines are also visible in the ornament and in the field. On the photograph the field is darker than the ornament, which shows that white-lead saturation on the field is much lower.

In the upper part of the candle details of the ornamental design were made on a thick groundwork of wax mixed with white lead, therefore they are not visible on the photograph. The section view of this fragment is given on Chart 2.

The data of the X-ray analysis were confirmed by the physico-chemical analysis of the colouring agents and wax. They are as follows.

1. Orange-red colouring agent

Spectral analysis revealed:

Basic elements: Pb, Fe

Admixtures: Mg, Si, Al, Ca

Traces of: Ti, Ag, Cr, Mn

Microchemical analysis confirmed that the colouring agent consisted of iron minium added to white lead

2. White colouring agent

Spectral analysis revealed:

Basic element: Pb

Admixtures: Mg, Si, Fe, Al, Ca

Traces of: Ti, Ag, Cu, Cr

Microchemical analysis confirmed that white lead was used as a colouring agent.

3. Blue pigment

The microscope showed that the surface of the blue details had been overpainted earlier.

The spectral analysis of the overpainting revealed:

Basic elements: Fe, Pb

Admixtures: Co, Mg, Si, Al, Ca

Traces of: Ti, Ni

The overpainting was made with an iron-containing colouring agent added to white lead. Microchemical analysis revealed that the pigment was Berlin blue added to white lead.

The spectral analysis of the pigment of the original layer:

Basic elements: Co, Pb

Admixtures: Ni, Ti, Mg, Si, Al, Ca

Traces of: B, Bi, Zr, Sr, Ag, Cu, V, As

Microchemical analysis confirmed that the paint consisted of white lead with cobalt-containing pigment (smalt).

4. Black colouring agent

Spectral analysis revealed:

Basic element: Pb

Admixtures: Ca, Si, Mg, Al, Cu

Traces of: Ti, Co, Fe

Microchemical analysis confirmed that the black paint consisted of white lead with soot added to it.

5. Green colouring agent

Spectral analysis revealed:

Basic elements: Cu, Pb, Fe

Admixtures: Si, Al, Mg, Ca

Traces of: Ti, Ag

Microchemical analysis confirmed the presence of copper-containing paint and green earth as admixtures to white lead.

6. Bright-red colouring agent

Spectral analysis revealed:

Basic elements: Fe, Pb

Admixtures: Mg, Al, Si, Ca

Traces of: Ti

Microchemical reactions showed that the pigment consisted of red ocher added to white lead.

The analysis of the upper wax layer on the field of the ornamental design showed that it contained 25-30 percent of white lead, most probably ground with warm wax, which is all visible under the microscope. Lime and quartz sand were used as fillers for the inner layer of the wax cylinder. Spectral analysis revealed the presence in the outer wax layer of white lead paint and also of a small amount of lime used for bleaching wax in ancient times.

The X-ray photographs of the fragments helped to make an attempt at establishing the original method of making the support wax candle and its ornamental design. The wax cylinder consists of three layers of bleached wax that was melted and applied on a rotating shaft layer after layer. Before the application of the upper layer to make the surface smooth, the candle was reinforced by hemp straps put in the wax when it was still warm. Then the contours of the ornamental design were carved on the outer, already smooth, surface of the wax cylinder. To get the desired tone, melted wax was mixed with white lead containing colouring agents and poured into a previously made relief 2-4 cm deep. To make the details of the ornamental design more prominent they were outlined by black and white wax that was poured into the specially carved grooves 1-2 cm deep. The ornament was not covered with drying oil or varnish.

Experimental work to select materials for the restoration of the "thin" candle and to determine the restoration technique was conducted on the basis of the data provided by X-ray and physico-chemical analyses.

Wax-colophony mastic was used to glue and fix the detached fragments. To deal with the cracks and ensure a more reliable attachment of fragments to

the body of the candle, hoops and clamps of sheet copper were used. Part of a hoop and several clamps are visible on the X-ray photograph, which will be of use when the exhibit is to be restored next time.

The missing fragment of the upper part of the wax cylinder was recreated by pouring wax in the form-work of thick aluminium foil installed on the walls of the "thin" candle. Cracks, missing pieces and dents on the inner and outer surfaces of the cylinder were filled with melted wax. On the ornament bleached wax was poured, then toned with natural umber to match the colour of the wax.

The spots of scale destruction on the walls of the "thin" candle were impregnated with hot wax. The oil paint layer was softened by thinners inert to wax, with subsequent treatment by alcohol-acetone mixture. The blue oil paint layer was not removed, for the wax underneath, toned by smalt added to white lead, was destroyed and assumed a whitish hue. The soilings were removed also by alcohol-acetone mixture.

MESURES INDIRECTES DE L'ETAT DE COHESION
DES PLÂTRES PEINTS A FRESQUE

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Groupe de travail: Nouvelles applications
de méthodes d'examen

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Résumé

Les méthodes physiques qui caractérisent les propriétés mécaniques des matériaux de construction des bâtiments sont inadéquates si l'on veut les appliquer aux peintures murales. Il est en effet souvent nécessaire d'évaluer en données numériques précises l'état de cohésion des plâtres peints à fresque. Dans ce but on a mis au point deux nouveaux appareils qui fournissent une mesure indirecte de la cohésion du plâtre par la résistance à la pénétration d'une pointe d'acier. Cette pointe soit avance sous la action d'un poussée constante soit tourne à vitesse et pression constantes. Ces données servent au restaurateur pour vérifier l'état de dégradation de la fresque et pour procéder par la suite à une intervention de consolidation appropriée. Ces méthodes d'analyse appliquées soit au laboratoire soit 'in situ', se révèlent toujours sensibles et reproductibles surtout en présence d'échantillons de peinture réalisés de façon homogène.

1 - Préface

Pour caractériser les propriétés mécaniques des matériaux de construction des bâtiments, on dispose de méthodes physiques normalisées qui sont appropriées. Ces méthodes se révèlent par contre complètement inadéquates si l'on veut les appliquer au domaine des oeuvres d'art.

En ce qui concerne par exemple le secteur plus restreint des peintures murales, il est souvent nécessaire d'évaluer en données numériques précises l'état de cohésion des plâtres peints à fresque.

C'est en effet un des paramètres les plus significatifs

pour la caractérisation de ce genre d'oeuvres . Il est bien connu que la cristallisation des sels à l'intérieur du mortier, les variations thermohygrométriques, l'aggression de la pollution atmosphérique et microbiologique sont des processus qui mènent à la désagrégation des plâtres ou bien, en d'autres termes, à l'altération de leur cohésion .

Le restaurateur essaye d'y remédier par des interventions de consolidation . Leur contrôle nécessite de nouveau une évaluation quantitative du degré de cohésion .

Il est donc nécessaire d'avoir à sa disposition des méthodologies appropriées pour mesurer cette grandeur physique . Comme il s'agit d'oeuvres d'art, il serait préférable de faire usage de méthodes de mesure dites non-destructives . Au cas où néanmoins ces dernières (qu'il s'agisse d'application d'ondes ultra-soniques ou électromagnétiques ou autres) ne peuvent être applicables et significatives, il est juste de s'orienter vers d'autres procédés même microdestructifs de réalisation plus immédiate et qui fournissent des résultats concrets en temps util .

Ces procédés sont indispensables au laboratoire lorsqu'on les applique sur des échantillons artificiels soit pour vérifier et confronter des méthodes de consolidation, soit pour l'étude des processus de dégradation . On peut d'ailleurs (en opérant avec prudence et en choisissant des zones opportunes) également en faire usage pour des mesures 'in situ' .

Dans un rapport précédent les auteurs ont proposé le emploi de deux instruments de construction simple, conçus dans ce but spécifique (1) .

Ces instruments fournissent une évaluation indirecte de la cohésion des couches superficielles d'un plâtre . L'appareil illustré en Fig.1 fournit des données sur la résistance d'une surface à la pénétration (P) d'une pointe cylindrique en acier 'vidia' qui avance sous l'action d'une force constante . L'appareil illustré en Fig.2 fournit par contre des données sur la résistance d'une surface à l'érosion (E) provoquée par une pointe tranchante (également en acier 'vidia') qui tourne en avançant sous l'action d'une pression constante .

Les essais de tarage de ces instruments, exécutés sur des échantillons de référence à cohésion homogène et préparés artificiellement avec du 'plâtre de Paris' et du sable, ont mis en évidence la sensibilité et la reproductibilité des mesures .

Les deux appareils fournissent en outre des valeurs qui s'accordent entre elles tout en étant basées sur des principes différents . Pour les épreuves présentées dans cet rapport nous avons effectué de petites modifications dans la forme de la pointe des deux appareils . Nous avons procédé par la suite à la vérification de la possibilité de les appliquer pour le contrôle des pro-

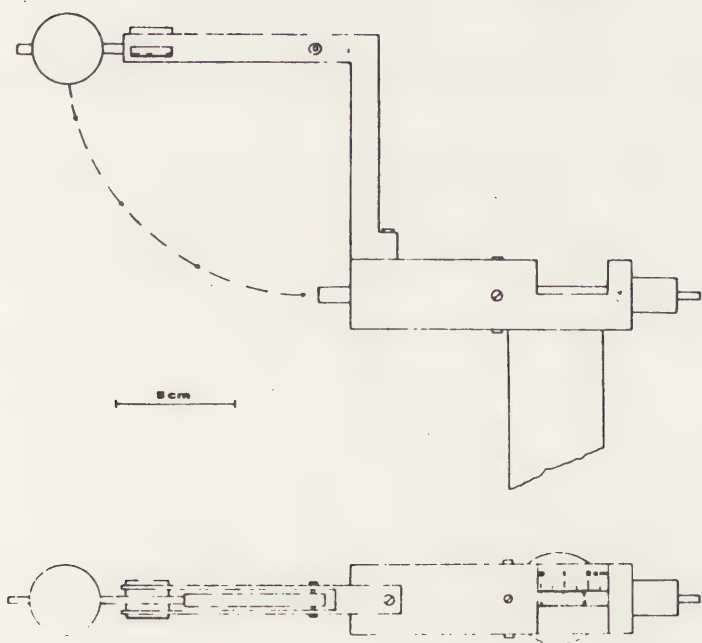


Fig. 1 - Dessein schématique de l'appareil a penetration (P).

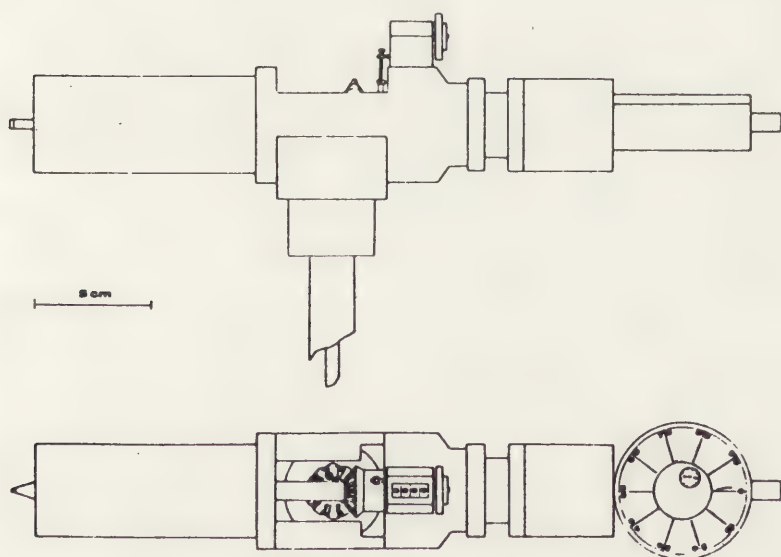


Fig. 2 - Dessein schématique de l'appareil a erosion (E).

cessus de consolidation des fresques soit au laboratoire soit sur place .

2 - Mesures de contrôle des traitements de consolidation au laboratoire .

Il est possible de réaliser au laboratoire des échantillons qui simulent la composition et la structure d'une peinture murale . Ces échantillons sont réalisés dans des conditions plus contrôlées par rapport à la réalité et par conséquent ils sont beaucoup plus homogènes du point de vue de leur composition chimique et de leur structure physique . Nous avons donc réalisé une série de plaques standard peintes en suivant fidèlement les procédés classiques employés dans la peinture à 'buon fresco' . Après un vieillissement naturel de plus ou moins 2 ans, la moitié de la surface de chaque plaque a été traitée par des procédés de consolidation à base d'hydroxyde de barium .

- Traitement A - Compressees d'hydroxyde de barium en poudre (dispersé à 15 % dans de la pâte de cellulose aqueuse à 10 %) appliquées pour une durée de 4 heures .

- Traitement B - On applique d'abord une suspension aqueuse d'aluminium en poudre sur une feuille de papier japonais étendue sur la surface de la couche picturale . Là-dessus on applique une compresse d'hydroxyde de barium (dispersé dans de la pâte cellulosique aqueuse à 10 %) qu'on l'aisse en contact pendant plusieurs heures (4-5) . Les rapports de poids entre $Ba(OH)_2/Al$ sont de 5/1 .

- Traitement C - Compressees de barium alluminé en poudre (dispersé à 15 % dans de la pâte cellulosique aqueuse à 10 %) pendant une durée de 4 heures environ .

Sur les plaques traitées de la sorte nous avons effectué une série de mesures à l'aide des deux appareils cités aussi bien dans les zones traitées que dans celles de référence . Les résultats ont été notés sur le Tab.1 .

3 - Mesures de contrôle des traitements de consolidation effectués sur des fresques 'in situ' .

On a effectué des mesures indirectes de cohésion sur des fresques d'époques et d'auteurs différents sur lesquelles, durant les travaux de restauration précédents, on avait procédé à des traitements de consolidation .

Malheureusement la casuistique qui était à notre disposition est limitée de par le fait que la plus grande part de ces fresques restaurées et consolidées n'ont pas de zones de contrôle non-traitées . Néanmoins il nous a été possible de trouver trois oeuvres sur lesquelles avait été effectué le traitement consolidant à l'hydroxyde de barium (traitement A) précédé par une com-

presse de carbonate d'ammonium à 30 % dans de la pâte cellulosique aqueuse à 10 % .

Dans un cas (échantillon ST) il y avait eu un traitement consolidant sur toute la surface à l'exception d'une petite zone en marge que le restaurateur avait laissé dans son état original . Dans les deux autres cas (échantillons CC et SC) il y avait par contre des épreuves de consolidation sur de petites surfaces de l'oeuvre alors que le reste avait été laissé tel quel .

Echantillons de fresques

ST - Santi di Tito - 'Cène à la maison du pharisien' XVI^e siècle
Réfectoire du couvent de la SS. Annunziata . Florence .

(10 ans après le traitement)

CC - Auteur inconnu - 'Scène de la vie franciscaine' XV^e siècle
Eglise de Cercina . Florence .

(7 ans après le traitement)

SC - Auteur inconnu - 'Décoration du soubassement' XVI^e siècle
Chapelle Baroncelli, Eglise de S. Croce . Florence .

(6 ans après le traitement)

Les résultats sont rapportés dans le Tab.2 .

4 - Discussion .

Les valeurs rapportées sur les deux tableaux expriment la profondeur de pénétration de la pointe (en millimètres) à l'intérieur du matériel dont on veut déterminer la cohésion . Ces valeurs ne sont significatives que si on confronte entre elles celles mesurées sur un même échantillon sur des zones traitées et non - traitées .

La valeur de la pénétration rapportée sur les tableaux, exprime la valeur moyenne et la déviation standard calculées pour dix déterminations . En outre on calcule la différence de pénétration (en pourcentages) entre la partie traitée et celle non-traitée .

Les valeurs de ΔP en % et ΔE en % rapportées sur le tableau 1 démontrent l'efficacité des traitements de consolidation qui avaient été effectués .

Il résulte que le traitement C est le meilleur pour la consolidation parce qu'il diminue la pénétration de 76 % (mesure effectuée à l'aide de l'appareil à percussion) et de 93 % (mesure effectuée à l'aide de l'appareil à érosion) .

Il ne nous est pas possible de préciser quelle relation il y a entre la diminution de la pénétration (due au traitement consolidant) et l'augmentation de cohésion du matériel . Dans ce rapport d'ailleurs nous ne nous sommes pas intéressés à exprimer des considérations sur l'efficacité des traitements consolidants mais plutôt à la mis en point des méthodes de recherche proposées pour l'évaluation quantitatives des traitements .

Tab. 1 - Valeurs de pénétration (en mm) sur des plaques simulant des fresques traitées avec des consolidants différents

Traitement	P	$\Delta P\%$	E	$\Delta E\%$
A	traité	2, 20 \pm 0, 27	2, 24 \pm 0, 42	
	contrôle	2, 88 \pm 0, 18	3, 87 \pm 0, 22	-24
B	traité	2, 01 \pm 0, 22	1, 78 \pm 0, 36	
	contrôle	2, 76 \pm 0, 26	3, 15 \pm 0, 30	-43
C	traité	0, 67 \pm 0, 13	0, 24 \pm 0, 20	
	contrôle	2, 75 \pm 0, 20	3, 28 \pm 0, 27	-93

Tab. 2 - Valeurs de pénétration (en mm) sur des fresques consolidées à l'aide du traitement A .

Fresque	P	$\Delta P\%$	E	$\Delta E\%$
ST	traité	1, 14 \pm 0, 42	1, 64 \pm 0, 62	
	contrôle	1, 25 \pm 0, 30	1, 89 \pm 0, 32	-9
CC	traité	2, 35 \pm 0, 50	2, 40 \pm 0, 62	
	contrôle	2, 53 \pm 0, 44	2, 71 \pm 0, 38	-7
SC	traité	2, 68 \pm 0, 48	2, 72 \pm 0, 52	
	contrôle	2, 81 \pm 0, 41	2, 95 \pm 0, 47	-5

Note : Valeurs moyennes et déviation standard pour 10 déterminations :

P - avec l'appareil de pénétration après 10 coups .

E - avec l'appareil d'érosion après 10 tours .

Pour la spécification des traitements et des fresques voir le texte .

Au cours des mesures effectuées sur des échantillons de laboratoire nous avons remarqué une influence sur la pénétration due au type de pigment présent dans la zone mesurée : les zones peintes en blanc sont plus résistantes à la pénétration que celles peintes avec d'autres pigments .

En examinant les données des mesures sur place (tableau 2), on remarque que les résultats ne sont pas aussi satisfaisants. En fait les différences des valeurs moyennes entre la partie traitée et non traitée n'apparaissent pas significatives . Il faut ajouter que pour chacune des mesures il nous est arrivé plus d'une fois de ne pas enregistrer de différences entre les zones traitées et non traitées . Dans quelques rares cas on a même enregistré des valeurs de pénétration supérieures dans les zones consolidées par rapport à celles de l'état original .

Les raisons de tels développements, il faut les rechercher dans la différence de cohésion originale du mortier de zone en zone . L'artiste ou plutôt l'apprenti, très souvent ne se souciait pas d'étendre les mortiers de façon à leur donner une cohésion rigoureusement égale et la technique d'exécution bien connue se basait par ailleurs, sur un travail à la journée (a giornata) .

En d'autres termes, il existe une série de paramètres indépendants qui font varier la cohésion du mortier d'un point à l'autre d'une fresque ; au point de provoquer des différences du même ordre de grandeur que les effets produits par des interventions de la consolidation, même si en effet la consolidation a été faite .

On peut affirmer, en concluant, la validité des méthodes décrites pour le contrôle au laboratoire des procédés de consolidation sur des échantillons de peinture murale réalisés de façon homogène et leur attribuer une bonne sensibilité et reproductibilité .

En effet le contrôle préliminaire de la validité d'un traitement est d'une grande importance avant d'opter pour son application sur l'oeuvre original .

Par contre, en ce qui concerne les contrôles directs sur les oeuvres traitées, il est nécessaire de pourvoir à priori à une série de détermination (à l'aide de la méthodologie décrite) sur des points bien définis dans la voisinage immédiat desquels on répètera les mêmes déterminations après la consolidation .

De cette façon seulement il sera possible de minimiser l'interférence sur les mesures qui est due à la variabilité non quantifiable du support .

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A proposal for two new methods to investigate the cohesive
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81/1/9

IR-SPECTROSCOPIC ANALYSIS OF AGED GELATINS

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ICOM Committee for Conservation
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Working Group: New Applications of Methods
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IR-SPECTROSCOPIC ANALYSIS OF AGED GELATINS

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Summary

IR-spectroscopy was used to study the samples of fresh soluble, naturally aged soluble (a flow of glue taken from a wooden sculpture of 1483) and insoluble (the same flow of glue) gelatin before and after heating the samples to $+210^{\circ}\text{C}$. The IR-spectra of the unheated samples were typical spectra of collagen or gelatin, with certain distinctions observed within the $1,460\text{--}1,380\text{ cm}^{-1}$ region. After heating, the Amide II band shifted to the range 1530 cm^{-1} in the soluble gelatin spectrum, the band at about $1,400\text{ cm}^{-1}$ disappeared in the fresh soluble gelatin spectrum, and its intensity decreased in the aged soluble gelatin spectrum. The IR spectra of unsoluble gelatin before and after heating did not differ in the $1,560\text{--}1,380\text{ cm}^{-1}$ region. The changes observed in IR spectra are discussed in connection with the probable structural alterations during the natural ageing of gelatins, including the formation of interchain bonds and removal of water molecules.

One of the most essential features of paint media is that these substances can be subjected to natural ageing during a long period of time /1, 2/. Since such paint media as egg-white or yolk are multicomponent mixtures consisting of various natural ^{com}pounds, many reactions are to take place in them during the natural ageing which change the initial properties of the medium components. But neither the changes in the properties of protein media components (denaturation, polymerization, etc.), nor the effect of non-organic compounds such as pigments on them, nor the reactions resulting from natural ageing are practically known. However, changes in the media properties may lead to the destruction of the paint layer and the ground primer. Therefore, the information about the natural ageing of the media is of considerable theoretical and practical interest. In the present study samples of fresh soluble and naturally aged soluble and insoluble gelatins were analysed by means of the IR-spectroscopy. As a result the assumptions were made about the processes taking place during the ageing of animal glue used as a binding medium for grounds of polychromic sculptures.

Materials and Methods

Samples. Three types of dried gelatins have been studied: 1) gelatine extracted by boiling of calf skin fragments at a temperature of $+60^{\circ}\text{C}$; 2) soluble gelatin extracted from of a flow of the glue taken on the back side of the sculpture of st. Victor, 1483, Holy Spirit altar, Tallinn; amino acid composition of this fraction was determined earlier /3/; 3) insoluble gelatin extracted from the surface layer of the same flow. Besides sample (1) has been studied after being UV-irradiated ($\lambda \sim 259 \text{ nm}$) for 2 hours.

IR spectra (KBr-pellets) were recorded by means of spectrophotometer "Specord IR 75" (K. Zeiss, Jena). The pellets were heated in a thermostat at a temperature of $+210^{\circ}\text{C}$ for 2 hours and the spectra were registered again.

Results and Discussion

In IR spectra of the samples recorded in the range $4,000\text{--}400 \text{ cm}^{-1}$ (fig. 1 gives the $1,800\text{--}1,200 \text{ cm}^{-1}$ region), bands Amide A ($\sim 3,310$), Amide B ($\sim 3,070$), Amide I ($\sim 1,655$) and Amide II ($1,540 \text{ cm}^{-1}$) typical for collagens or gelatins /4,5/ are seen. Comparison of the spectra of samples 1-3 before heating revealed certain distinctions in the range $1,460\text{--}1,380 \text{ cm}^{-1}$: in the sample 1 spectrum there was a doublet at $1,457$ and $1,400 \text{ cm}^{-1}$; the same doublet and an arm at $1,390 \text{ cm}^{-1}$ were seen in the sample 2 spectrum (this spectrum is similar to the IR spectrum of the soluble gelatin extracted from the ground of Rubens' painting /6/); and in the sample 3 spectrum there was a band at $1,450 \text{ cm}^{-1}$ with an arm at $1,390 \text{ cm}^{-1}$. As it is known /7/, the bands in the range in question are due to deformation vibrations of -C-H groups, and symmetric stretching vibrations of -C=O groups of -COO^- ionized groups.

To conceive the essence of the distinctions particularly between the spectra of the soluble gelatin (samples 1 and 2) and insoluble gelatin (sample 3), the samples have been heated since it is known that at a temperature above 140°C , the gelatin becomes gradually insoluble, forming the its structure characterized by a number of lateral interchain bonds, and at $205\text{--}211^{\circ}\text{C}$ supercontraction is taking place that is an irreversible process caused by the destruction of the three-chain (collagen-like) regions into separate chains /8/. In the course of heating water evaporates and the gelatin becomes practically insoluble when its water content is reduced below 1 per cent by weight /9/. It may be assumed that heating somewhat simulates the process of natural ageing and causes greater structural changes in the samples of the soluble gelatin than those in the insoluble ones. As to sample 3, its insolubility is probably due to a greater number of interchain and between-chain covalent bonds in the gelatin which was on the surface of the glue flow and which, therefore, was affected to a greater degree by external factors than the inner layer of gelatin remained soluble (sample 2).

Indeed, after heating the samples to 210°C (the point at which irreversible structural changes take place in the soluble gelatin /8/), considerable changes were seen in the IR spectra (fig. 1, b - the dotted lines). In particular, in the spectra of heated soluble gelatins (samples 1 and 2) Amide II noticeably shifts to the range $1,530\text{ cm}^{-1}$ and the shape of Amide I band somewhat changes, this one can assign to the evaporation of water from the samples /4,9/; however, Amide II does not shift in the sample 3 spectrum after heating.

Greater changes were observed in the range $1,560\text{--}1,380\text{ cm}^{-1}$ where the band at $\sim 1,400\text{ cm}^{-1}$ disappeared in the gelatin 1 spectrum; in the sample 2 spectrum 10-

ticeable decrease in the intensity of this band was seen and a distinct narrow band at $1,390\text{ cm}^{-1}$ appeared. The IR spectrum of sample 3 did not practically changed in this region. Such differences between IR spectra of samples 1-3 must be considered due to the structural changes which may take place in the gelatins exposed to high temperatures.

It is known that acid and basic functional groups determine many physical properties of the collagen fibre /10/. It should be noted that glutamine and asparagine acids taken together account, on the overage, for 15 per cent of the amino acid content of collagens and gelatins /3, 10/. High temperatures make the gelatines lose water molecules, which, on the one hand, may cause structural changes, and, on the other, a shift of the isoelectric point of the gelatin. The shift of the isoelectric point may be accompanied by the change-over of $-\text{COOH}$ groups into $-\text{COO}^-$ form and vice versa, which, in its turn, may make for the disappearance of the band at $\sim 1400\text{ cm}^{-1}$ in IR spectra of samples 1 and 2. It may be assumed that the number of $-\text{COO}^-$ groups decreases along with the evaporation of water from samples 1 and 2, whereas the water content in sample 3 is so insignificant that high temperatures do not diminish it any further and there are practically no free $-\text{COO}^-$ groups. The stability of the water content in sample 3 is also testified to the fact that Amide I and Amide II bands do not shift in the spectrum of the heated insoluble gelatin. We can not assign the band at $1,390\text{ cm}^{-1}$ in the IR spectrum of the heated insoluble gelatin to any vibrations of a particular group.

Low intensity of the band at $1,400\text{ cm}^{-1}$ was also observed in the IR spectrum of the sample 1 gelatin exposed to ultra-violet irradiation (the source with the basic wave-length of 259 nm) (fig. 1, c). It is known that irradiation of a gelatin with the light at

a wave-length over 240 nm results in photopolymerization of molecules, with the amino acids of non-helix regions of the molecules most probably involved first /11/. Judging the decrease in the intensity of the band at $\sim 1,400 \text{ cm}^{-1}$, the process of photopolymerization proceeds along with the structural changes due to probable removal of the water molecules.

The results obtained let us to conclude that in the course of natural ageing of the gelatin exposed to air for a long time the most water molecules are removed from the gelatin for ever and the structures appear with many inter- and between-chain bonds. Glutamine and asparagine acids residues probably take part in the formation of covalent bonds since there are γ -glutamyl bonds between molecules in collagens /10/, whereas the arm at $1,400 \text{ cm}^{-1}$ in the insoluble gelatin spectrum may indicate that this gelatin contains but very few free $-\text{COO}^-$ groups. Though the properties of the gelatin in inner layers of the flow of glue changed less than that on the surface, and it remained soluble for 500 years, certain changes did occur in it, for the IR spectra of the fresh and old soluble gelatins after heating differ to some extent. We do not know thus far in what way non-organic components of the grounds affect the process of natural ageing of the gelatins, but the fact that the insoluble /3/ and soluble /6/ gelatins were both found in the grounds of the old paintings points to the probability of identical processes of the structural changes in the gelatins taking place irrespective of whether the grounds contained non-organic components or not.

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Fig.1. IR-spectra of
unheated (a) and hea-
ted (b) gelatins;
c - IR-spectrum of
UV-irradiated sample 1

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METHODES SCIENTIFIQUES D'EXAMEN A METTRE
EN OEUVRE POUR AMELIORER LES CONNAISSANCES
DE LA TECHNIQUE PICTURALE DES PRIMITIFS
FLAMANDS

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Comité pour la conservation de l'ICOM
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Groupe de travail: Nouvelles applications
de méthodes d'examen

METHODES SCIENTIFIQUES D'EXAMEN A METTRE EN OEUVRE POUR
AMELIORER LES CONNAISSANCES DE LA TECHNIQUE PICTURALE DES
PRIMITIFS FLAMANDS

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Résumé

L'étude que nous avons menée sur l'évolution du modelé de la peinture flamande du XV^e et XVI^e siècle a mis en évidence la carence de documents techniques et, en particulier, de coupes transversales, tant d'oeuvres de grands peintres que de maîtres secondaires. Pour remédier à cette situation qui nous a dans bien des cas empêché de dépasser le stade des hypothèses, il faudrait étendre les examens technologiques dans le cadre d'un programme établi en collaboration avec les scientifiques attachés aux institutions conservant les oeuvres étudiées. Une première approche consisterait à appuyer les hypothèses de travail émises en utilisant plus largement la réflectographie dans l'infra-rouge et la radio-graphie et en développant l'analyse de la couche picturale par microfluorescence x.

L'historien d'art qui étudie les primitifs flamands manque souvent de données ponctuelles et objectives se rapportant à leur technique picturale. Cette carence l'empêche de dépasser le stade des simples hypothèses. Ainsi l'étude de l'évolution du modelé pendant la période allant de Van Eyck à Colyn de Coter, examinée sous les 2 aspects du dessin sous-jacent et de l'exécution picturale, a soulevé plusieurs questions importantes que nous avons dû laisser sans réponse parce que nous ne disposions que de documents trop fragmentaires ou peu démonstratifs (1) . L'interprétation, dans une perspective évolutive et diachronique, des données fournies par l'étude visuelle des oeuvres mêmes et par les examens de laboratoire a mis en évidence des modifications dans le dessin sous-jacent et une simplification de la structure picturale liée à une transformation de son principe de construction.

Résumons brièvement les conclusions auxquelles nous sommes arrivées.

La structure picturale stratifiée, très élaborée des grands Primitifs flamands, se simplifie au cours du XV^e siècle. Le nombre de couches superposées diminue et leur rapport transparence-opacité se modifie. Dans ce domaine les oeuvres de Memling, Van der Goes, G. David ont peu retenu l'attention des historiens d'art. Or, elles illustrent non seulement les tendances de modèles de la 2^e moitié du XV^e siècle mais elles annoncent aussi, à des degrés divers, l'orientation que prendra la technique des petits maîtres brabançons de la fin du siècle. Ce processus de réduction des couches de couleurs, et des glacis en particulier, pourrait être élucidé avec plus de rigueur si l'on disposait d'un échantillonnage plus abondant de coupes transversales.

Dans les tableaux de Van Eyck la luminosité du modelé est obtenue par la transparence des couleurs et la réflexion de la lumière sur la préparation blanche ou le ton de base clair. Ce ton translucide est déjà modelé de l'ombre à la lumière par addition progressive d'une faible quantité de blanc de plomb. Toutefois ce sont les glacis qui assurent la profondeur du modelé. Dans les oeuvres des petits maîtres brabançons, dont fait partie Colyn de Coter, au contraire, la luminosité provient de l'addition d'une forte quantité de blanc au ton de base et de vigoureux empâtements extérieurs.

Une évolution s'est donc marquée dans l'usage du blanc de plomb. Sa distribution quantitative dans le modelé qui permet dans une certaine mesure comme l'a démontré K. Wolters (2), de reconnaître un style, ne nous semble pas constituer un critère suffisant à prendre en considération. Il y aurait aussi lieu de préciser sa localisation au sein des couches picturales ainsi que sa fonction prioritaire.

Au cours du XV^e siècle, cette fonction nous paraît avoir été multiple. Ajouté en faible quantité aux couleurs, ce pigment paraît servir essentiellement à nuancer le modelé chez les Primitifs flamands de la première moitié du XV^e siècle. Toutefois, suivant les différents maîtres, on rencontre des modalités d'exécution qu'il faudrait pouvoir définir autrement que par le seul examen des oeuvres et de quelques radiographies. Le blanc de plomb employé par Memling ou Van der Goes sous la forme d'une couche plus ou moins dense qui se rapproche de la surface, pourrait assurer au modelé un complément de luminosité mais obtenu au dépend de la profondeur. En effet le regard est arrêté entre le ton moyen, opacifié par l'addition de blanc, et le glacis léger posé en une seule couche. Ce blanc pourrait aussi remplacer la source lumineuse de la préparation claire, tendance qui se dessine dans certaines oeuvres de G. David mais qui sera développée par les petits maîtres brabançons et par Colyn de Coter en particulier.

En effet, la lumière qui émane du fond, n'étant plus perceptible à travers les couleurs opaques, sera le plus souvent remplacée par des additions de pâtes extérieures au modelé.

Ces observations conduisent à des interrogations.

S'agit-il véritablement d'une strate de blanc posée sur le ton moyen ou plutôt de l'addition de blanc en plus forte proportion au pigment ? La différence optique entre la couche légère de Memling et la couche plus dense et d'aspect laiteuse de Van der Goes, est-elle due à une différence d'épaisseur et de niveau de profondeur dans la structure ? Comment caractérise-t-on par rapport à celle de Van der Goes la couche de blanc employée par Colyn de Coter, qui paraît encore plus épaisse et qui semble surtout ne plus être recouverte par un glacis. Annonce-t-elle la technique d'empâttement lisse de Breugel ? ou est-ce seulement le résultat d'une simplification visant à faciliter l'exécution. Enfin comment expliquer sur coupe la différence de luminosité des carnations en clair-obscur peints par Van der Goes et G. David et à partir de quand les hautes lumières crèvent-elles les glacis ?.

Le traitement des ombres se modifie aussi au tournant du XV^e siècle. Les ombres translucides de type eyckien obtenues uniquement par la multiplication des couches en glacis, atteignant dans l'ombre la plus profonde le maximum de saturation chromatique, se réduisent à une seule couche chez Memling et Van der Goes, souvent relevée de rehauts graphiques foncés. Au terme de cette évolution dans les oeuvres de Colyn de Coter, l'ombre devient opaque et est mise en une couche épaisse.

Dès lors qu'elle a perdu sa transparence cette couche peut-elle être encore considérée comme un glacis ? ou doit-on y voir ce que nous avons appelé un " glacis simplifié " ? et à quel moment la coloration de l'ombre est-elle due à l'addition d'un pigment bleu, brun ou noir ? Nous pensons en relever des exemples, décelables à l'oeil dans des oeuvres exécutées autour de 1510-1515, mais il serait nécessaire de mieux situer dans le temps cette modification technique très importante (3).

Enfin, les structures des vêtements bleus et des brocarts apparaissent très schématisées lorsqu'on les compare à celles mises en oeuvre par les Primitifs flamands, elles devraient être étudiées au départ d'un plus grand nombre d'oeuvres et être illustrées par des documents techniques, notamment des radiographies et des coupes transversales.

Dans les bleus peints par Colyn de Coter on observe une différence entre l'aspect extérieur du modelé, qui présente une juxtaposition brutale de plages claires et foncées, et sa structure interne livrée par la radiographie, le ton moyen bleu semble être mêlé d'une forte quantité de blanc sur toute la surface du vêtement, même dans les creux des plis, c'est-à-dire dans les ombres plus profondes qui sans une telle adjonction, ne devraient pas apparaître en radiographie (3).

Dans les lumières l'azurite additionnée de beaucoup de blanc revêt l'aspect d'une couche lisse et laiteuse laissée à nu. Dans les ombres ce pigment est couvert d'un "glacis simplifié" d'épaisseur variable, empâté et très foncé dans les parties les plus sombres.

Dans les oeuvres d'atelier la structure du bleu paraît encore plus simple. Une épaisse couche d'azurite, mêlée à une quantité de blanc plus forte encore que dans les oeuvres de Colyn de Coter, et donc d'aspect plus opaque, modèle la forme. Elle est recouverte uniquement dans les ombres d'une couche de bleu d'une épaisseur telle que la couche sous-jacente n'est plus du tout perceptible. Ce bleu foncé apposé en dernier lieu empiète d'ailleurs sur les parties claires.

Seules des coupes transversales prélevées sur plusieurs tableaux permettraient de vérifier si cette structure est bien caractéristique de la peinture de la fin du XV^e siècle.

L'exécution des brocrats devient de plus en plus rapide. Alors que Van Eyck, Van der Weyden et Bouts rendaient leur texture par un modelé progressif du ton de fond vers la lumière et un jeu d'épaisseur de fils ors, les petits maîtres brabançons schématisent ce modelé élaboré ou leur substituent un système graphique plus sommaire. Ils peignent les motifs le plus souvent à plat, sans tenir compte des plis du tissu, sur un ton moyen couvrant qui n'est plus modelé, les plages foncées ou claires alternant de manière purement décorative, tandis que les stries de lumière ont une même densité sur toute la surface. En outre le passage de la lumière vers l'ombre est simulé dans le tracé des motifs et des fils par l'usage de deux tons différents, le jaune dans de hautes lumières et le rose dans les moyennes, tandis que l'exécution des parties situées dans l'ombre est très relâchée. Cette différence de structure relevée lors d'un examen au binoculaire et de la lecture des radiographies demanderait à être confirmée par des coupes ; cela n'a pas encore été fait et l'étude de l'exécution des brocrats apporte précisément des éléments d'appréciation sur la qualité de l'oeuvre et permet entre autres de distinguer la main du maître de celle de ses élèves.

La modification la plus significative du dessin sous-jacent est liée directement à l'évolution du modelé. C'est la disparition du dessin de mise en place au profit d'une multiplication des plans de hachures. La manière de représenter et de distribuer ces plans qui marquent les ombres, change elle-même progressivement. Les plans de hachures qui suivent d'abord le sens des formes, sont petit à petit supplantés par des plans de hachures mis à plat. Dans les premiers la profondeur de l'ombre est indiquée par un tracé plus ou moins appuyé ou par une trame plus serrée, dans les seconds seul l'emplacement de l'ombre est marqué en

tant que surface sans qu'il n'y ait de préfiguration du volume.

Cette évolution du dessin, qui n'a pas encore retenu l'attention des historiens d'art, mériterait d'être approfondie grâce à l'étude de plus nombreuses photographies dans l'infrarouge et ou de réflectogrammes d'oeuvres maîtresses, encore peu ou mal documentées, ainsi que d'oeuvres des petits maîtres brabançons, si négligées jusqu'à présent. Enfin si l'on veut disposer d'une vue d'ensemble du modelé il faudrait étendre les recherches aux oeuvres de Q.

Meetsijs, J. Gossart et Van Orley, à propos desquelles les matériaux de référence sont étrangement rares.

Le développement de plans de hachures et l'affranchissement vis à vis de l'écriture structurée et orientée des Primitifs flamands, semble avoir eu pour corollaire l'apparition d'un outil autre que le pinceau : la pierre noire.

Au vu de documents infrarouge actuellement en notre possession, Memling semble être parmi les Primitifs flamands l'utilisateur le plus fréquent de cet instrument convenant d'ailleurs particulièrement bien au caractère d'esquisse et au tracé nerveux propre à ses dessins sous-jacents à partir des années 1479-1480. G. David semble aussi l'avoir employé entre autre dans les " Adieux du Christ à sa mère ".

Quelle est la nature exacte de cet instrument, le "Mariage Mystique de Sainte-Catherine" et le "Tryptique Moreel" sont-ils les deux premiers tableaux où il a été utilisé ?

G. David s'en sert-il dans ses oeuvres maîtresses comme "La Vierge entre les Vierges" de Rouen, les petits maîtres brabançons l'ont-ils aussi employé ? Autant de questions auxquelles un plus large échantillonnage de documents techniques permettrait sans doute d'apporter une réponse.

En conclusion nous sommes convaincus que les historiens d'art pourraient résoudre pas mal de problèmes pendants posés par les tableaux des Primitifs flamands à condition de disposer de données scientifiques plus étendues.

Lorsque les documents existent on devrait y avoir accès sur demande, en échange d'une collaboration avec les scientifiques de l'institution les détenant ; un échange de vue dans un cadre précis de recherche serait la démarche la plus fructueuse.

Il est fréquent que les coupes transversales provenant de prélèvements effectués au hasard des restaurations, ne conviennent pas au but recherché. C'est pourquoi il est nécessaire d'élaborer un programme de recherches au départ d'oeuvres en bon état de conservation et pour lesquelles on possède déjà des photographies dans l'infrarouge et des radiographies renseignant sur l'élaboration du modelé.

Les prélèvements ponctuels de matière sur les peintures risquant le plus souvent de porter atteinte à l'intégrité de l'oeuvre, nous voudrions suggérer d'utiliser plus largement une méthode non destructive comme la microfluorescence x qui

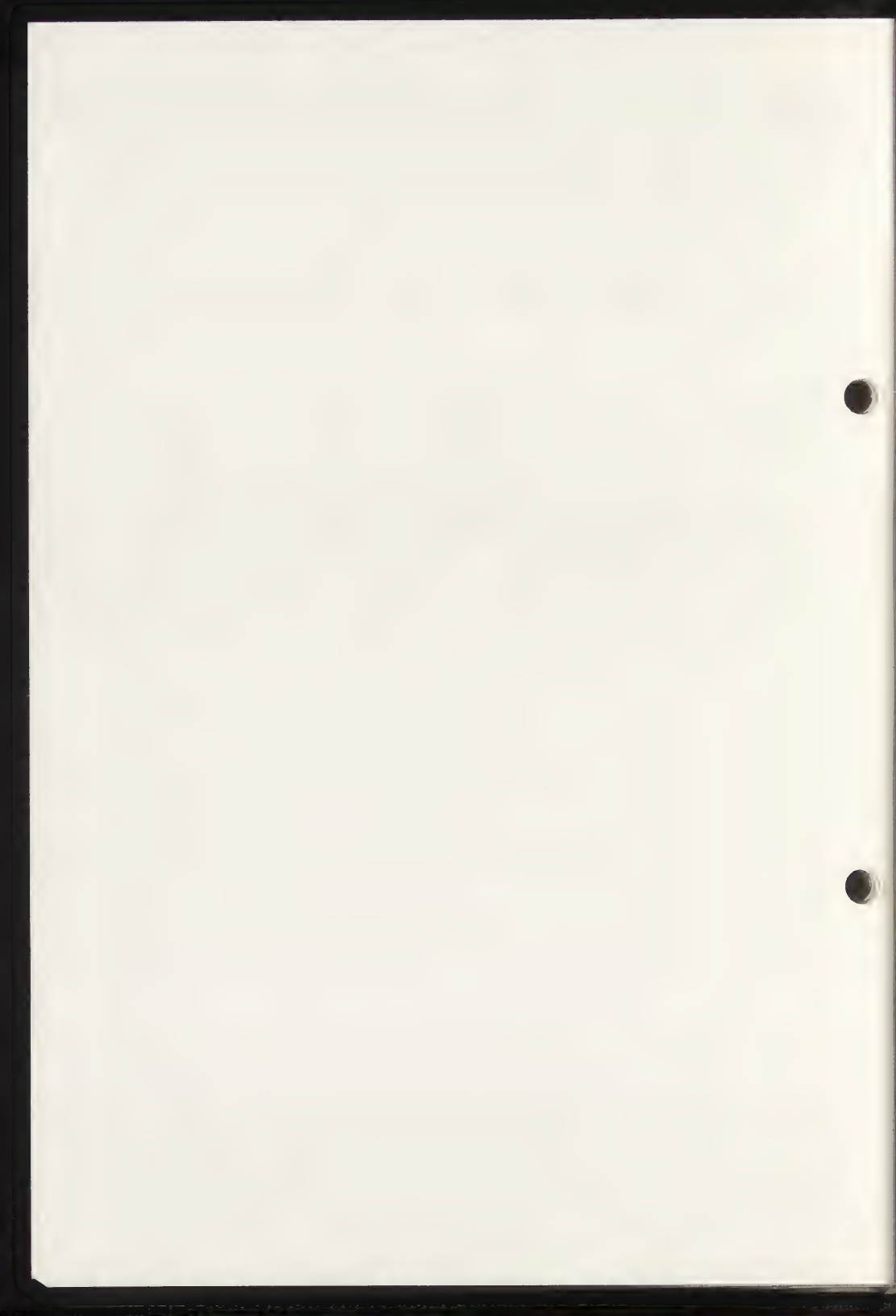
permet par ailleurs d'analyser toutes les parties de la couche picturale, même celles où on ne peut effectuer de prélèvements.

Par ailleurs les méthodes physiques d'examen demandent elles-mêmes à être développées et surtout usitées dans un contexte de recherche bien orienté ; de trop grandes lacunes subsistent encore dans ce domaine, même lorsqu'il s'agit des oeuvres importantes des Primitifs flamands. Nous souhaitons donc susciter pour la prochaine réunion de l'ICOM une collaboration internationale entre scientifiques pour étendre les recherches en cours. Une étude ponctuelle de plusieurs oeuvres clés à définir aiderait à caractériser la manière individuelle des peintres flamands et permettrait de mieux suivre les transformations techniques essentielles apparues entre le début du XV^e siècle et la première moitié du XVI^e siècle. Elle améliorerait la connaissance de la peinture flamande de cette époque et les observations rassemblées contribueraient à une approche meilleure des problèmes d'attribution et du travail d'atelier.

Les questions posées ci-dessus nous paraissent un champ d'action tout indiqué pour le groupe des nouvelles applications de méthodes d'examen . Les scientifiques auront ainsi l'occasion de mettre en oeuvre les moyens techniques dont ils disposent en vue de proposer pour interprétation des données objectives encore inexploitées.

Notes

- (1) Les hypothèses de travail émises ont été développées dans notre Thèse de Doctorat sur Colyn de Coter et les ateliers brabançons de la fin du XVe et du début du XVIe siècle, présentée à l'Université Libre de Bruxelles en avril 1980.
- (2) Ch. WOLTERS, die Bedeutung der Gemäldedurchleutung mit Röntgenstrahlen für die Kunstgeschichte, Francfort Prestel Verlag, 1938.
- (3) Filedt KOK a relevé dans les ombres des vêtements bleus du Tryptique du Jugement Dernier de Lucas van Leyden l'usage d'une couche de blanc de plomb sous l'épaisse couche d'azurite. L'oeuvre date de 1526 - 1527 . Colyn de Coter aurait-il utilisé antérieurement une technique comparable ?
- J.P. Filedt KOK, Underdrawing and other technical aspects in the painting of Lucas van Leyden, in nederlands Kunsthistorisch Jaarboek, 29 (1978) 1 - 184 , Harlem, 1979.



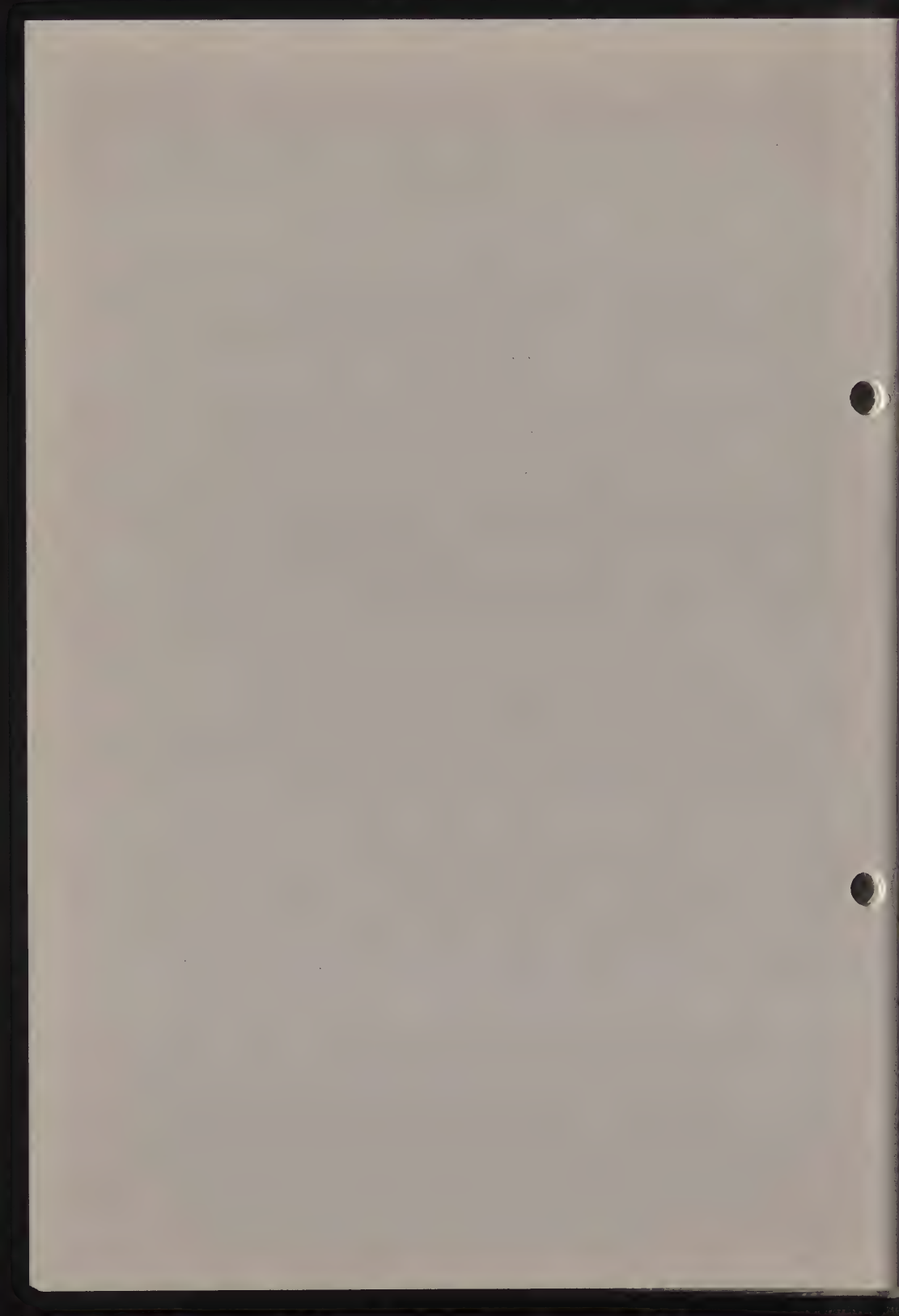
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THE COMPLEX INVESTIGATION OF THE GROUP
PORTRAIT FRESCO OF IAROSLAV THE WISE
(1046) IN KIEV SOFIA CATHEDRAL AND OF
FOUR FRESCO PORTRAITS OF QUEEN TAMAR
(THE END OF THE XIIITH-XIIIITH CENTURY

Igor Gilgendorf

ICOM Committee for Conservation
6th Triennial Meeting
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Working Group: New Applications of Methods
of Examination



THE COMPLEX INVESTIGATION OF THE GROUP PORTRAIT FRESCO
OF IAROSLAV THE WISE (1046) IN KIEV SOFIA CATHEDRAL AND
OF FOUR FRESCO PORTRAITS OF QUEEN TAMAR (THE END OF THE
XII-TH-XIII-TH CENTURY)

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Very seldom the art monuments of the past reach the present in their original shape. Particularly it is concerned the medieval monumental paintings which during their existence underwent the influence of atmosphere, numerous renovations, corrections. They were covered with plaster and painted once more accordingly to the given epoch. Miserable remainders which were left after the removing of the plaster and exposing of the original painting are very inconvenient for art experts, historians and restorers. The visual study is not enough for solution of such problems as the dating, stylistical classification. It is nearly impossible for clarifying the masters handwriting and technic.

The modern technical means of investigation, the use of the ultra-violet ultra-red and X-ray came to the aid. They give the possibility to see the vanished part of the fresco, its details, the colours of later restoration, corrections and even the sketches of the painter. Besides that one may read the extincted inscriptions and thus on the ground of all findings come to the corresponding scientific conclusion.

This article tells about the complex method which was used during the investigation of the Iaroslav the Wise portrait in Kiev Sofia monastery /1046/, which was repainted many times and after the exposing gave rise to the opposite conclusions of scientists and four life-time fresco portraits of Georgian Queen Tamar /the end of the XII - the beginning of the XIII centuries/ in Vardzia, Betania, Khintsvisi and Bertubani monasteries.

"The monumental painting is the art which is applied to the vast human groups taking into account the interaction and fine contacts with human individuality and with mass as well. By the force of its social significance and peculiar possibilities of artistic expression the monumental painting completely reflects the move of the social conceptions, the formation of the ethic ideals, changes in the social and the state life".

"... the monumental painting can interact with architectural forms", "it can promote the adoption of the inner significance of architectural image and at last, it utilizes its peculiarities for the solution of complicated tasks, as e.g. the task of imitative and real space intercourse of the definite historical period or permanently lasted phenomenon, which bears the answer to eternal idea".¹

Thus the investigation and the study of the monumental painting sets the great responsibility upon the "investigation process and especially upon the results - scientific conclusions".² Unfortunately, very often the condition of the monumental paintings which reach the present days hampers and in some cases even excludes the possibility to solve the problem of dating, stilistical classification and discern different individual handwritings. As an example for the previous we may give the monumental painting of the middle XI cent. in Sofia Cathedral in Kiev, where in 1946 the fresco was completed - the group portrait of the founder of the cathedral - Iaroslav the Wise.

1. The study of the Russian medieval monumental painting, O.I. Podobedova, Moscow, 1980, p. 7.

2. See the same.

In the course of time the painting was faded, crumbled and was flooded under the leaked roof. In the beginning of the XVII cent. the painting was partly renewed by glue colour and on the boundary of the XVII-XVIII cent. the badly damaged painting was plastered and whitewashed. Later in the XVIII cent. the fresh images were painted in oil against the plaster. A piece of the plaster accidentally fall down and thus the fragment of the XI cent. frescoe was exposed. After the fragment was examined, the academitian Solntsev got the permission to crumble down the rest of the plaster and to restore the old painting. The work was fulfilled in the extremely rough methods. After the plaster was removed the icon-painter Pashekhonov began to paint upon the frescoe, at first followed the old abris, but then he left the abris and went on to paint up to his discretion, using the material of inferior quality. As a result the fulfilled part of his work was grew mouldy. Then the painter desided to cover the mould by brushing it with boiled oil. After that the restoration of the painting was completed by another icon-painter in 1850. The rest of the fragment of the frescoe in the nave of the south wall was covered with figures of martyress.

The exposure of the frescoes was started in 1928. Only in 1952 when the restoration committee was founded the restoration works dot the regular character. At present the restoration was completed, but because of the barbarian ways of previous restoration the frescoe is still badly damaged. Nearly all the inscriptions and names of the saints are obliterated and there is no a single letter on the group portrait. All these and the absence of any historical information make a great problem for the scientists and investigators of the Sofia Cathedral painting. Particularly it concerned the group portrait of the Iaroslav the Wise in definition of which still there is no any common objective scientific concusion; who is depicted on the preserved frag-

ment, daughters or sons, how they were dressed and who is who?

V.N. Lazarev considered that the four preserved figures on the south wall central nave are the portraits of Iaroslav's daughters, and on the north wall - sons and that the whole composition consisted out of 13 figures. In the centre - Christ, on the left the princess Irina with five daughters, on the right prince Iaroslav with five sons.³ S.A. Visotsky thinks that the left side from Christ was occupied by prince Vladimir and Iaroslav with sons, and the right side - by Olga and Irina with daughters and that the whole composition was consisted out of 15 figures.⁴ Poppe agreed with Visotsky in figure arrangement but denies the presence of Vladimir and Olga in the composition.

S.A. Visotsky considers that the preserved figures are the sons. In his definition he refers to Abraham Van Vesterfeld's drawing /I65I/ and Solntsev's watercolour /I853/.

Such difficult case can be solved only by the help of the modern technical means of investigation.

With this aim we made the complex investigation of this frescoes by ultra violet, ultra red rays and by X-ray emission.

The three figures underwent the reflected ultra violet and infra red rays and the visible ultra violet luminescence.

The heads of the first, second and fourth figures and the clothes were investigated too. The control fotoes were made in every case of investigation by means of this or that method.

3. V.N. Lazarev, Byzantian and Old Russian Art, Moscow, 1978, p. 112-115.

4. S.A. Visotsky, What did the old walls tell, Kiev 1978, p. 55-60.

During the study and investigation of the monumental painting in Kiev Sofia Cathedral the art experts revealed not only the questions of dating, stilistical classification, but also the technics of different masters, for as A.B. Lazarev considers, several masters worked on that group frescoe. So A.B. Vinner has no doubts that the group portrait frescoe completely was painted in ground colours and the lime was used as the whitening.

The investigation of the head of the first figure /from left to the right/ by X-ray emission at once disproved Vinner's assertion about the use of the lime whitening. The X-ray emission gave the clear image of the earliest sketch of this figures head; the head-dresses with the crown is seen clearly while observed by naked eye the head seems to be covered with a scarf.

The following investigation of the fragments of the second and fourth figures gave the same results. Then the luminescence, provoked by the same ultra-violet, reflects the bright-white colour, that points to the presence of the white lead. The following microchemical examination acknowledged the presence of the lead. Thus the painter utilized not the white lime, but the white lead.

Besides the X-ray emission and the visible ultra-violet luminescence the invastigation was carried out with the use of the reflected infra red and ultra violet rays. As it was mentioned, all the heads of the four preserved figures are smooth and the head-dresses are not observed.

As a result of the complex investigation we got the fotoes in which are clearly marked out the remnants of the basic colour layer of the frescoe, the technique of fulfilment, revealed the ornaments on the dresses, the shape of the head-dresses /as it came out they were not the same/, and the remnants of the later colouring mainly on the dresses.

All these facts are quite a new information for the art experts. The information needs the thorough study and

interpreting which help the experts to come to the scientifically-grounded conclusion and to answer a number of unsolved questions.

X-ray emission was carried by means of the equipment which allowed to press the technical photographic film directly upon the frescoes. Then we started irradiation by impulse X-ray camera " " with cold cathode with 160 kilovolt tension and the 3 minute exposure.

The photography by ultraviolet and infrared rays was carried out in an ordinary way with the use of the corresponding light filters and special material.

The complex investigation of four lifetime portraits of queen Tamar in Vardzia, Betania, Kintsvisi and Bertubani monasteries is carrying out at present.

According to I. Djavakhishvili - "the preserved portraits of queen Tamar besides its artistic merits are interesting because they are the monuments of medieval Georgia, when it attained its political and cultural flourishing.

According to the historian of queen Tamar - Basili "she was the wise and impartial ruler.", "... the person of great gifts she built her foreign policy on active collaboration with Caucasian peoples; armenians, ossetians, shirvanians and etc."

Our investigation gives the possibility to expose all, that is lost to the eye and thus to the investigator too: the smallest details, individual technic peculiarities, restoration corrections, losses of the original fresco layer.

We got the possibility to make the exact comparison of these portraits, to see the painter's handwriting by superposition the character of his dabs and a number of scientific information. Now it is possible to make new, quite interesting conclusions.

The first investigation of the portrait of queen Tamar which goes back to 1207 was made in the church in Be-

tania. The complete investigation of all portraits will be finished by May 1981. The dome of this church crumbled and burried the north wall where the frescoe of queen Tamar with her father George III and the son George-Lasha were placed. In the middle of the XVIII c. the church was visited by G.Gagarin. He cleared the obstruction and swept the frescoe from the dust. The frescoe was damaged from dust and atmospheric influences. In the foto it is observed very well how during the 50-60 years period the portrait is faded, many details vanished: the drawing of the crown is scarcely seen, the face is grey, the colour layer falling out and under the scrupulous examination of the face is observed the rough drawing of the eyebrows, eyes, nose and lips. It gives the feeling of another hand, but not of the another of the portrait. The portrait is very artistic and monumental and produces the great impression in spite of the losses and faded colours.

The foto in infra red rays exposed all details of the shape of the trimmed crown and original colour layer is observed very well. The original sketch of the face with steep wide eyebrows and lengthen eyes is vividly observed. The crack in the plaster which is filled up with the plaster cast is seen along the left side of the face from the temple up to the centre of the chin. The ultra violet luminescence exposed the presence of the white lead. Pearls and the collar gave the luminescence of bright white colour. The same is observed on the face, but less. Probably the white lead was used in the colouring of the face too.

The most expressive is the foto which was made in close ultra violet rays. It clearly exposes that the preserved drawing of eyebrows, eyes, nose and lips were made later. The eyebrows here are thin and unacreted. The shape of the eyes is not so prolonged, the nose is smaller. The whole impression of the face is calm, a little fatigue. The glance is soft, the oval of the face is round.

The whole colouring of the face which was probably made at the same time with the sketching of the nose, brows and mouth is observed too. The dabs on the forehead and around the eyes are of clear character. And, at last, the x-ray emission exposed the whole face with the middle part of the crown and the neck. First of all the X-ray exposed all losses which had been restored later. It is concerned the right chick just beginning from the nose up to the right temple.

Thus we may say with certainty that the portrait was restored, renewed and in the result it changed the appearance and the impression of the face.

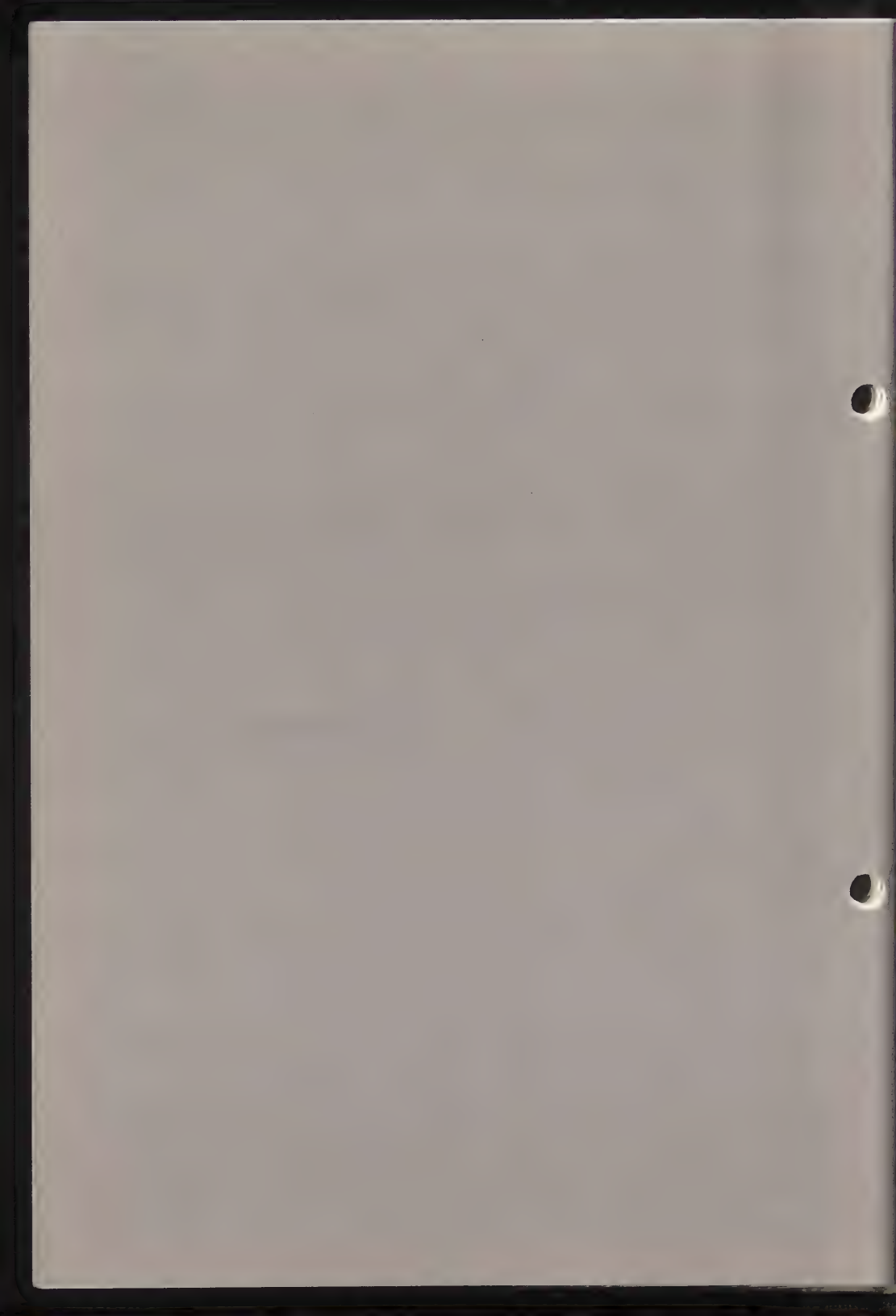
81/1/12

LA RECONSTITUTION PHOTOGRAMMETRIQUE ET
PHOTOGRAPHIQUE DE LA GROTTÉ DE LASCAUX

Christian Lahanier

Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981

Groupe de travail: Nouvelles applications
de méthodes d'examen



LA RECONSTITUTION PHOTOGRAMMETRIQUE ET PHOTOGRAPHIQUE DE
LA GROTTÉ DE LASCAUX

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SOMMAIRE

La reconstitution d'une grotte et de son décor a nécessité la mise au point et l'emploi de technologies variées. En effet le relief exact des parois et les peintures ont été relevés par des méthodes stéréophotographiques et photographiques. La construction de la structure résulte de technologies nouvelles de décorateur de théâtre. Enfin les peintures rupestres sont reproduites par une innovation photographique à partir de transfert de décalcomanies.

La célèbre grotte de Lascaux découverte en 1940 est fermée au public depuis 1963. Les magnifiques peintures néolithiques qui datent d'environ 17000 ans ne peuvent plus être visitées car la présence du public provoquait des altérations par le gaz carbonique exhalé et par les microorganismes transportés. Il fallut faire appel aux scientifiques pour conserver les peintures en voie de dégradation. C'est pourquoi Madeleine Hours, Conservateur en Chef des Musées Nationaux, a décidé de réaliser une

reproduction de la salle des Taureaux au Grand Palais à l'occasion de l'exposition "La Vie Mystérieuse des Chefs d'Oeuvre, la Science au service de l'Art".

Cette performance technique a nécessité la collaboration de quatre équipes de recherche :

- le relevé du relief de la grotte, la prise de photographies couleur de l'ensemble des peintures furent confiés à l'Institut Géographique National,
- la construction grandeur nature de la structure exacte de la salle des Taureaux a été réalisée par les Unités Théâtrales et Recherches de Villeurbanne,
- la réalisation du décor (peinture rupestre) a été obtenue grâce à la collaboration des Laboratoires de Recherche de la Société Kodak,
- le Laboratoire de Recherche des Musées de France, responsable technique de l'ensemble du projet a coordonné et participé activement à la réalisation des travaux.

L'Institut Géographique National avait effectué en 1966 un relevé photogrammétrique de la grotte de Lascaux à partir de couples stéréophotographiques. De ces clichés, les courbes de niveau correspondant aux profils exacts de la salle des Taureaux ont été tirés au 1/10, verticalement et horizontalement tous les 25 centimètres. L'ensemble de ces profils a ensuite été reproduit photographiquement en grandeur nature. D'autre part, 25 clichés photographiques couleur de format 18x24 centimètres ont permis de relever l'ensemble des peintures rupestres. Le relief accidenté des parois et les conditions draconiennes imposées par le contrôle du climat de la grotte furent à l'origine de nombreuses difficultés pour réaliser cet enregistrement.

La fabrication de la structure du fac-similé confiée à la Société Unités Théâtrales et Recherches de Villeurbanne

banne est un ouvrage remarquable. Ces profils verticaux et horizontaux, grandeur nature, ont été reproduits par des découpes dans du contre-plaqué. Ces fragments ont été assemblés pour constituer 27 modules indépendants de 1,25 mètre de large et de 3 mètres de haut. Ces derniers juxtaposés pour former la paroi supportent une voute constituée d'éléments de 1,25 mètre de large et d'environ 6 mètres de long. Ces modules présentent une structure alvéolaire formée par l'emboîtement des profils horizontaux et verticaux. Ce macrorelief exact mais ajouré de la surface de la grotte a été rempli par des blocs de polystyrène expansé arasés tous les 25 centimètres selon la courbe des profils en bois. Chaque bloc fut ensuite modelé pour obtenir le microrelief des parois rocheuses en respectant au maximum les détails observables sur les photographies. Après dépôt sur la surface de ce moule provisoire en polystyrène d'une couche de latex, on projette avec un équipement spécial un mélange de résine polyester, de catalyseur et de fibres de verre produisant une surface polymérisée dure et incombustible de 5 millimètres d'épaisseur environ. La surface de polyester fut ensuite recouverte de sable et d'ocre jaune et rouge afin de reproduire l'aspect réel de la roche.

Chacun des 25 clichés photographiques des peintures rupestres a été tiré dans un format de 1,80x2,40 mètres c'est à dire grandeur nature. Ces tirages ont été assemblés selon un montage modèle réalisé préalablement.

La mise au point par les Laboratoires de la Société Kodak d'un procédé de transfert décalcomanique à partir des tirages photographiques a permis de reproduire fidèlement sur un relief accentué les peintures préhistoriques. Le montage photographique grandeur nature fut découpé en 200 épreuves de 80x60 centimètres. Chaque épreuve fut collée par sa face émulsion sur un papier pour décalcomanie. L'image photographique fut séparée de son support primitif. Chaque

épreuve fut alors appliquée et collée à l'emplacement prévu sur la surface de la grotte. Le papier décalcomanie une fois humecté se détache facilement de la gélatine qui adhère même dans les plus petites infractuosités de la paroi. Les modules une fois assemblés, on procède aux retouches indispensables. Un éclairage judicieusement atténué met en valeur le relief par des jeux d'ombre. Ainsi grâce à ces performances techniques le public peut maintenant connaître la grande Salle des Taureaux, une des plus belles parties de ce joyau du patrimoine français.

STRUCTURAL RESTORATION OF CANVAS PAINTINGS

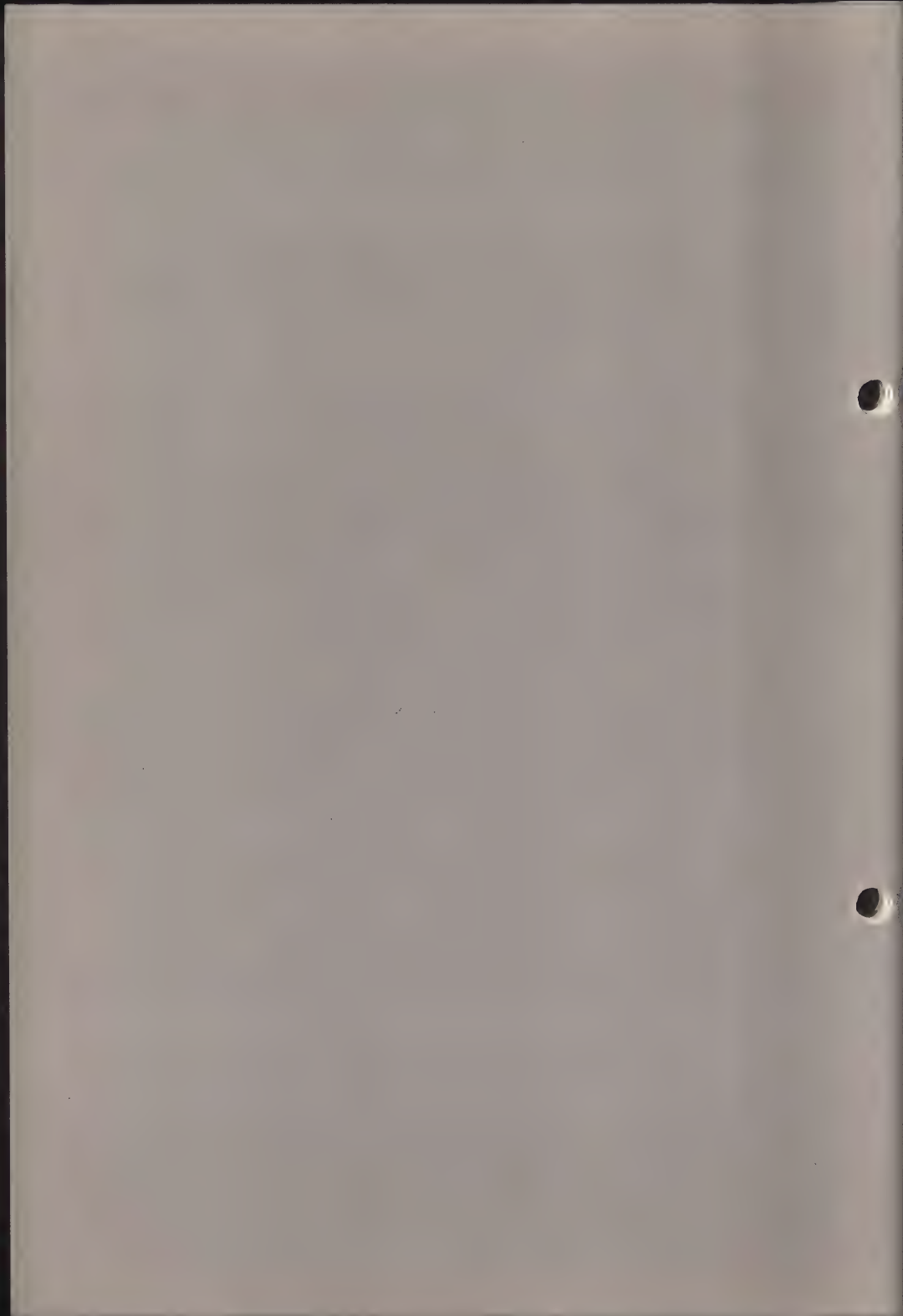
Coordinator : W. Percival-Prescott (U.K.)

Assistant coordinator : P. Boissonnas (Switzerland)

Members : S. Bergeon (France)
 G. Berger (USA)
 M. Bjarnhof (Denmark)
 B. Hacke (Denmark)
 B. Hallström (Sweden)
 G. Hedley (U.K.)
 Y. Lepavec (France)
 R. Levenson (USA)
 G. Lewis (U.K.)
 V. Mehra (Netherlands)
 J. Seddon (U.K.)
 M. Sotton (France)
 E. Stöbe (Austria)
 J. Voskuil (Netherlands)
 R. White (U.K.)

Programme 1978-1981

1. Consolidation techniques, including aspects of filling and retouching (Berger).
2. Coordinated research into stress/strain relations in paintings on canvas (Hedley, Mehra, Voskuil a.o.).
3. French traditional lining techniques and their practical development (Part II) (Bergeon, Lepavec, Sotton).
4. Supporting paintings on canvas without lining (Lewis)
5. The role of the adhesive (Boissonnas).
6. Blanching of paint structures (Percival-Prescott, Hallström, White).
7. Relaxation of distorted paintings and related lining studies (Hacke, Bjarnhof, S. Bjarnhof).
8. The topography of the paint surfaces (Levenson).
9. Fillings and simulation of painted surfaces (Seddon).
10. Traditional panel press lining techniques from Vienna (Stöbe).
11. Aspects of vacuum envelope and suction lining techniques (Percival-Prescott a.o.).



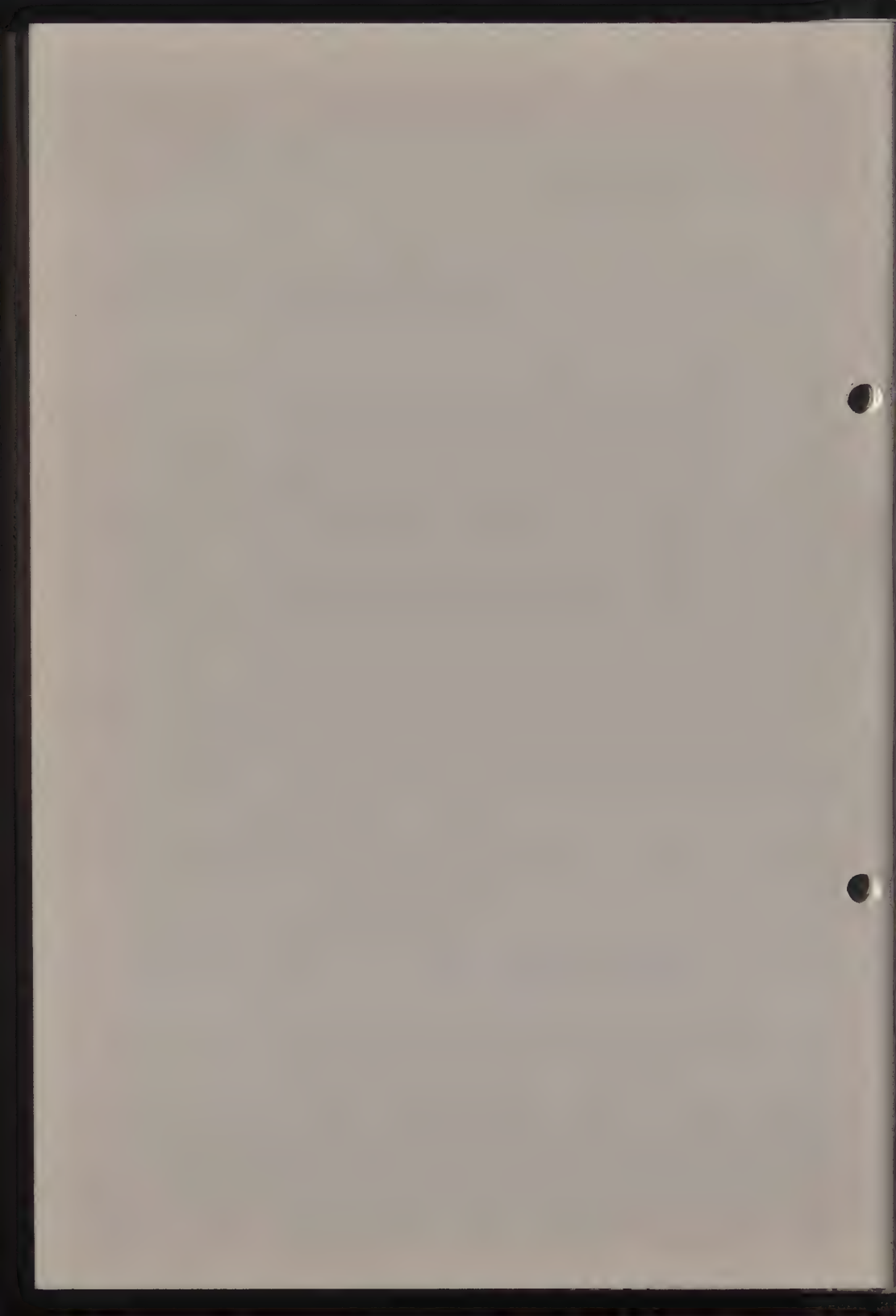
81/2/1

ARTISTS CANVASES. A HISTORY

Caroline Villers

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Structural Restoration of
Canvas Paintings



ARTISTS CANVASES. A HISTORY

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The use of woven textile supports for paintings goes back to Ancient Egypt. In Europe, however, little survives prior to the 15th C. As we shall see this does not in itself argue against an earlier and continuous tradition of use, since it is clear that the vulnerability of the support and perhaps the technique used, account for the failure of these works to survive. The following paper sets out to survey what we do know of the use of textile supports from the evidence available and draws attention to the repeated selection of linen, which remains the favourite support to this day. The traditional use of animal skin glue is considered as a factor in the deterioration of the painting. About 150 years after their widespread adoption textile supports had begun to deteriorate sufficiently for lining to become a routine procedure, and it is not surprising that in selecting a suitable fabric the conservator also tended to prefer linen. Compared to other available natural fibres linen was a sensible choice, however, today many synthetic fibres exhibit superior chemical and mechanical properties that might make them preferable both as painting supports and lining materials.

EARLY PAINTINGS ON CANVAS. HISTORICAL BACKGROUND

In Europe fabric begins to dominate over wood as a painting support during the 16th C., but there is ample evidence for the existence of paintings on fabric before that date. The wills and inventories of the citizens of Douai, Tournai and Louvain in the Southern Netherlands indicate that it was slightly more common to own paintings on fabric than on wood in the 15th C. In Italy the Medici Inventories of the 1490s list a surprising number of paintings, large and small, secular and religious, on fabric. In England the records of the Probate Court of Canterbury also indicate the possession of more works on fabric than on wood. 1

The Manuscript of Jean Le Bague, transcribed in France in 1431, contains references to textile supports for painting. A method that

seems to contain the essentials of a technique that remained prevalent in Northern Europe for several centuries is described in Eraclius Book III, generally assumed to be a 13th C. French document:

"If you wish to paint a linen cloth and lay gold upon it prepare it thus: Take parchment or clippings of parchment and put them into a jar with water which must be placed over a fire and made to boil as before directed, then dip a cloth into it, take it out immediately and stretch it onto a wet panel and let it dry. Then burnish or polish it all over with a glass muller and stretch it out fastening it onto a wooden frame with the thread. You may then paint on it with colours distempered with size or gum or egg" (Merrifield, Treatises I, p. 230). 2

The use of a chalk ground is the most common variation. Paintings executed in this technique may have been either cheap mass produced images, or individual works of high quality, like 'The Entombment of Christ' by Dieric Bouts (National Gallery, London) painted c. 1455. It is painted in an aqueous, probably gum medium on fine linen (20 warp 20 weft approx. per cm²) and has a very thin brown, pigmented chalk ground. Perhaps the earliest surviving example is 'Virgin and Child with Angels' by Malouel (Museum Dahlem, Berlin-Dahlem, on loan) painted 1405-10. Malouel was employed at Dijon by the Dukes of Burgundy who also owned paintings on fabric supports that have not survived. In 1387, for instance, the painter Jean Beaumez was paid for two such works, one at least in colour. 3

Other kinds of paintings on fabric include civil and religious banners, a variety of temporary decorations and those outstanding examples, the painted substitutes for tapestries for which Roger van der Weyden was famous. It is interesting that in Bruges there were separate Guilds of Painters and Cloth-painters, and together with the Embroiderers Guild, the Painters were aggressive in trying to limit their spheres of activity. In one instance they tried to prevent the Cloth-painters using an oil medium. Banners were sometimes painted in oil, but in general, it seems reasonable to suggest that paintings on panel were executed in oil and those on fabric in watercolour 4. Where it has been possible to check extant 15th C. Netherlandish paintings (Tüchlein) this is the case. Similarly when Pieter Breughel or Dürer painted on cloth they also used aqueous media. Van Mander's Schilderboek 1604 confirms this impression (e.g. Lives of Pieter Koeck, Lucas and Marten van Valkenbergh, Hans Bol) and he mentions the existence of 150 workshops at Malines specialising in landscapes, in watercolour, on fabric supports. However, by this time canvas was already predominating over wood and De Mayerne's Manuscript (1620) reflects this change. It is interesting that where artists continue to work on both wood and canvas, as Rubens and Rembrandt did, although consistently painting in oil, their techniques vary considerably with the support: they remain more traditional on wood and freer, more spontaneous on canvas.

The obvious implication is that paintings on fabric supports were very common, and yet relative to panel paintings few have survived. The technical innovation is not the use of fabric itself, but that of painting in oil on fabric, which actually occurs in Northern Europe later than in Italy. From the point of view of conservation it may be agreed that the use of aqueous media contributed as much as the fragile nature of the support to the deterioration and disappearance

of these early paintings.

In Italy Cennino Cennini (Thompson pg 103-108) also gives quite a long section about painting on various fabrics. There are no instructions for what we would call independent paintings, but the preparation of a banner sounds familiar.

"In the first place stretch it taut on a frame ... go around and around with little tacks to get it stretched out evenly and systematically so that it has every thread perfectly arranged ... take 'gesso sottile' and a little starch or a little sugar ... but first put on an all over coat of this size ... and it would not matter if the size were not as strong as for gesso ... and the less gesso you leave on the better it is; just so you fill up the interstices between the threads".

Cennini recommends the same medium, egg, as for panel paintings. A very early example of this technique applied to painting is "The Intercession of Christ and the Virgin" (Cloisters, New York). It is known to have stood on an altar in Florence Cathedral before 1402, and the vertical format and fact that it was only painted on one side preclude the possibility that it was a banner. It is a monumental work, 242.5 x 156.5 cm and made up of several pieces of cloth.

It seems that painting on fabric did not become popular in Central Italy as rapidly as it did in the North, so it is particularly striking that the earliest example of a painting in oil on canvas is Florentine: Uccello's "St George and the Dragon" (National Gallery, London) c. 1460. The extraordinary structure of the ground draws attention to the innovative and perhaps experimental nature of the work. Bromelle has discussed the painting in the context of other Florentine works on canvas and draws attention to the fact that whereas all Uccello's "Battle of San Romano" panel paintings survive other canvas paintings of secular subjects that were with them in the "Camera di Lorenzo" in the Medici Palace in 1492 were described as torn and damaged in 1598 and have subsequently disappeared. 5

Eastlake drew attention to the records of paintings in the Veneto in the 14th C. being "executed in the German Manner on cloth", 6 and works by Mantegna from the second half of the 15th C. certainly recall Netherlandish techniques. The earliest securely dated example is "St Eufemia" (Gallerie Nazionale di Capodimonte, Naples) 1454 catalogued as 'tempera'. All the examples on fabric in the National Gallery, London are in an aqueous medium or egg tempera and on very fine linen, the finest is "Samson and Delilah" 30 warp 30 weft approx per cm². The monumental "Triumphs of Caesar" (Hampton Court) are painted in egg tempera on a twill canvas. Vasari also says that both Jacopo and Gentile Bellini frequently painted on fabric, and that Gentile's paintings in the 'Hall of the Great Council' of the Doges Palace were executed on canvas in 1476. One of the earliest surviving Venetian oil paintings on canvas is Giovanni Bellini's "Madonna and Child with the Doge Barbarigo and Saints" (Murano, Church of St Peter Martyr) dated 1488. By the time Giorgione and Titian were painting oil on canvas had come to predominate. Vasari noted this development in Venice and suggested entirely practical reasons for it: unlike wood, canvas did not split or harbour worms, it could easily be obtained in the desired sizes and it was light and easy to trans-

por^ (Maclehouse, Vasari pg. 236-7). Certainly the wet and salty atmosphere of Venice was unsuited to the survival of monumental panel paintings or frescoes. Perhaps slightly surprisingly transport does seem to be a major concern and motivation for using canvas. In a letter concerning a commission in 1477 Mantegna wrote "I do not understand since your excellency wants them so quickly in what manner they are to be done. In a drawing only or in colour. On a panel or on canvas and what size. If your lordship wants to ship them far away they should be done on thin canvas so they can be wrapped around a little pole". (CG Ibert Italian Art pg. 12).

The ease with which a painting could be rolled up also becomes the criterion for a successful size or ground layer and the Venetian writer Borghini (*Il Riposo* pg 172, pg 175-6) draws particular attention to the preparation of Netherlandish paintings on fabric which could be easily rolled up and transported without cracking or flaking. In fact the Bouts "Entombment" was once in the Foscari Collection in Italy and possibly may have been part of an altarpiece painted for export.

It is debateable how much these practical considerations disguise a more profound change in the nature and function of paintings, but it is, nevertheless, striking that we have no record of purely aesthetic preferences being expressed. The use of coarser weaves and different weave patterns introduced greater textural variety into Venetian paintings. Although the artist must have made a personal selection and sometimes been aware of the novelty of his choice, no record survives and the examination of one artist's canvases, Tintoretto's, failed to reveal any logic or consistency for often his canvases are made up of pieces sewn together with apparent indifference to the surface effects of the location of seams, direction of weave, or patchwork finish. 7 Similar problems can be found in the work of Rubens or Rembrandt. Surveying the Tate Gallery's questionnaires to contemporary artists the expression of practical rather than aesthetic reasons also predominates with regard to supports, and again the balance is difficult to assess. A continued preference for linen canvas, for example, is generally linked to the ability to afford it or the desire to be aligned with tradition, often tradition as defined by handbooks like Doerner's, artists suppliers or the market. This often contrasts with attitudes expressed towards paint media or pigments or other items incorporated into a painting.

SIZE

Obviously deterioration problems cannot be attributed to the textile support alone, since the behaviour and survival of the support will also be influenced by the treatment it receives before painting. The traditional practice of pumiceing to remove knots and loose threads weakens a canvas stretcher design and the stretching process must be called into question and Marion Mecklenberg has pointed out 8 that, among other causes of problems, it would appear that one of the most active layers in the painting composite is the glue size layer. He suggests that dessication can lead to very large stresses in the size film which can lead to fracture in the paint and ground layers. Linen and cotton are traditionally associated with the use of size. Not only are they frequently sized by the artist, but they are often sized at least on the warp threads during weaving. Typical aqueous

responsive sizes used include locust bean size, starch sizes like Farina (potatoe starch size), sage flour size. Cotton yarn is customarily more heavily sized than linen yarn. One manufacturer supplied the information that in 16 oz linen approximately 3% of the weight of the fabric is accounted for by size. Synthetic based sizes are also used.

Historically some of the problems posed by the use of size were taken account of by writers on painting techniques. Various types of size were available, but there was a general preference, clearly expressed from the 17th century on, for one made from young pigs skin, kid or glove cuttings, because it remained soft and flexible whereas parchment size "being strong and harsh causes a certain shrinking of the canvas which has a bad effect" (Volpato, Merrifield II pg. 728. Also Symonds, Beal pg. 86; Pacheco Bk III, ch V, pg 71; Palomino Vol II Bk V pg. 484; Felibien ch V pg 295; De Mayerne, Van de Graaf No 9 pg 139). De Mayerne implies there was some controversy over this, his own experiments favoured kid or young goat skin size "in which all the skill consists, because if the size is too strong the canvas cracks and breaks easily; Van Somer however, used "strong size"/ "colle forte" and Van Dyck strong Fish Glue. Both unsuccessfully it seems (Van de Graaf No 15 pg. 140; No 8 pg. 139). Additions of honey which were common in English recipes from 1648-1748 (all based on Salmon's Polygraphice pg. 161) would have created different problems and again De Mayerne records the practice (Van de Graaf No 4 and No 7 pg. 138) while pointing out that the canvas then absorbed so much moisture it became too slack and the paint blanched.

Having selected the correct type of size it was also thought important not to apply either too much or too concentrated a solution: "let it (the size) neither be too weak nor too strong; for if too weak it will not defend the canvas from the oil and if too strong it will cause the colour to crack. That which is of the proper consistency will be soft like jelly when it is cooled" (Volpato, Merrifield II pg. 728. Also Symonds, Beal pg. 86; Palomino Vol II ch IV pg. 484).

not surprisingly Northern writers are more concerned with the size swelling than with it becoming too brittle, thus causing cracking and cleavage, but both fairly consistently recommend the application of only one or two coats of soft weak size. Of course there are exceptions. Writing in Venice in 1578 Armenini recommended entirely saturating the canvas in size applied from the back as well as the front (Armenini, Bk II ch VIII pg. 171). Occasionally there are recommendations to omit the size altogether (Pacheco Bk III ch V pg. 172), although more often commercial primers are blamed for doing this and so causing paint to dry matt (De Mayerne, Van de Graaf No 6 pg. 138; Symonds, Beal pg. 86).

Commercially primed canvases begin to predominate from the end of the 17th C. and traditional practice to the present day remains the application of size followed by an oil ground. To avoid some of the problems associated with size in the 18th century Dossie recommended immersing the entire canvas in hot drying oil (Dossie pg. 203). A less drastic solution was the use of Viscose, proposed in 1901 by Church, Professor of Chemistry at the Royal Academy, and then by a Committee of the Academy in 1928,⁹ it was in fact taken up by Winsor

and Newton who produced a canvas sized and primed with Viscose called 'Rcyac', which had the reputed advantages of being resistant to 'destruction by moisture' and preventing 'tightenings and saggings observable in strained canvases during changes in atmospheric conditions and that a fertile cause of cracking may be removed by the adoption of this treatment' (1934 Catalogue). Ultimately 'Royac' failed due to lack of response among artists. Currently synthetic polymer emulsions are being widely used especially for canvases with acrylic grounds.

Two reasons are commonly cited for the sizing of canvas by artists. One is that it is necessary to prevent cellulosic materials from coming into contact with oil paint. This need is of course specific to cotton and linen fabric, although it is worth noting that there is very little evidence available to quantify the effects of such contact. The other is that the ground layer needs to be prevented from penetrating through to the back of the canvas. This problem continues to exist with modern alternative fabrics and emphasises that not only would a material that does not require sizing with animal glue be required, but that this must be related to suggestions as to the most suitable types of ground.

THE CHOICE OF TEXTILE

During the 16th century Venetian Artists might have chosen from linen, hemp, fustians, silks, fine woollens to paint on. Cotton was briefly manufactured in Spain from 14th-15th C. and in fact a factory was set up near Venice at the end of the 14th C., although it never flourished. So the apparently consistent choice of linen is as notable then as its continued selection by contemporary artists is now. Undoubtedly flax was the most important vegetable textile fibre in domestic use. Hemp, another bast fibre, may be spun and woven on the same machinery and its production was well established in Italy in the 15th century, large quantities were in fact required to equip the Venetian fleet, but so far only one Venetian canvas Tintoretto's "Last Judgement" (Venice, Church of Madonna dell'Orto), has been cautiously identified as hemp 7. Improved forensic analysis made it possible to identify the canvas of Poussin's "Worship of the Golden Calf" (National Gallery, London) as positively hemp and it seems to have been more widely used in France and Italy during the 17th century. In 19th century French writers quite frequently recommended hemp over linen because of its superior strength (Bouvier ch XXX pg. 508), but its use has not been identified yet. Anthea Callen has pointed out that Paillot de Montabert (1829) while fundamentally opposed to the use of any textile support at all, still expressed approval for hemp. However, she found only one 19th C. catalogue, G Sennelier's, listing it for sale as a prepared artists canvas and that in 1894 10.

When 19th century French artists wanted to choose a coarser fabric they seem to have selected ones woven from jute (Hessian, Burlap). Jute was introduced into Europe about 1795, but modifications were required to flax spinning and weaving machinery to deal with its harsh fibres, so that it did not become widely available until its production was mechanised in Britain during the 1830s. By 1855 machinery was being exported from Dundee to India where the

fibre originated. By 1888 Van Gogh was already experimenting with Burlap followed by Gauguin who continued to use it in Tahiti as a matter of choice. It was first sold in Britain as a prepared artists canvas by Rowney and Co in 1913, Quality 'H' (not named until 1926), as a 'coarse rough cheap canvas for sketching purposes and for Art Students painting in a broad style'; the current catalogue contains the sensible warning that 'Jute has a limited life and this canvas can only be recommended where price is the prime consideration and the life of the painting is immaterial'. Winsor and Newton introduced Jute canvas between 1920-25, but had ceased to market it by 1948, and their catalogue also carried the warning that it was 'not recommended for permanent work'. It remains widely available. Jute mixtures have also been sold, in 1936 for example, Rowney introduced Quality 'M', a Flax/Jute mixture. Doerner had already expressed approval for this combination in 1921 11, although he rejected Hemp/Jute mixtures. In the Guggenheim Museum, New York, there are examples of Burlap being used by Léger, Ernst and Klee in the 1910s and it is striking that several had already been lined by 1953/4, only 40 years after they had been painted. Léger's 'Contrast of Forms', 1913, was lined in 1953. Jute is an example of an extremely poor fibre being selected by artists quite rapidly after its mechanised production had begun, and its marketing by Artists Suppliers following afterwards. Another bast fibre, Ramie, has the opposite history. It was recommended by a Committee of the Royal Academy in 1928 9, because of its superior fibre strength as a textile for artists canvases, but in spite of some enthusiasm in the 1930s it was never widely manufactured, was not sold by Artists Suppliers and has not been used by artists since.

Rapid experimentation with Jute contrasts with the history of cotton canvases, which have only become widely used for their intrinsic properties approximately 150 years after their introduction. As cotton is so widely used today, it is worth briefly surveying its history. In Europe developments in spinning and weaving techniques progressed minimally between 14th-18th C. and these techniques, suited to dealing with long bast fibres, were entirely unsuited to raw cotton. Cotton was imported in large quantities via Venice, but the distaff and spindle that continued to be used for spinning it, could not produce a cotton yarn combining strength with fineness. It could only be used as a weft yarn in fustians. However, the arrival of vast imports of cheap cotton from America and the West Indies encouraged inventions, and all the new machines that were invented were specifically designed for cotton rather than flax. The most important of these were Hargreave's Spinning Jenny and Arkwright's water-frame spinning machine both patented in 1769. Crompton's Mule also developed at this time, was better suited to spinning warp as well as weft yarns. Significant developments in the weaving process were Kay's 'Flying Shuttle' patented in 1738, and Cartwright's Power Looms, patented 1786-8, which enabled the entire process to be industrialised in factories. In 1790s Ginning machines were introduced in America for mechanically removing the cotton heads from the plant. 12

The mechanisation of flax spinning and weaving lagged about 50 years behind cotton. Shortages imposed by the American Civil War en-

couraged experiments and finally led to the design of the flax spinning machine patented by Kendrew and Porthouse in 1787. Kay's Flying Shuttle was introduced into Ireland for use in flax weaving in 1776, but thirty years later in 1807-9 premiums were still being offered for its use. It was only between 1839-54 that the most successful power looms for flax weaving were developed in Britain 13. It is reasonable to assume that from this date machine woven linen canvases began to be sold. Wehlte states that the French firm of Lefranc gave 1867 as the year in which they began to sell machine woven prepared linen canvas and the German firm of A Schutzmänn 1844, 14. Between 1840-1900 Winsor and Newton catalogues exemplify the steady expansion of the variety of available weave types and weights. After the 2nd World War the selection was reduced to only four types and for 10 years the best quality 'Winton' was unavailable. Despite wartime restrictions, strenuous efforts were made to maintain the sale of linen canvases. In spite of the early mechanisation of cotton spinning and weaving processes it was slow to gain support as an artists canvas.

At the beginning of the 19th C. Bouvier (ch XXX pg. 508) rejected it as too weak and an examination of French Colourmen's catalogues by Anthea Callen has shown that the first named reference to prepared cotton canvases 'Madapolam Toile' was in 1855 by Lefranc and Cie., when it was prepared for pastel drawings only and cost 2 francs less per metre than linen. The earliest mention of its sale specifically for oil painting is in 1894 in G Sennelier's Catalogue and 1896 in Lefranc's catalogue although there is insufficient evidence for this to be taken as the precise date of its introduction. Winsor and Newton supplied the information that cotton was introduced into their range of prepared artists canvases between 1900-06. The 1906 Catalogue lists a 'School of Art Canvas' as a 'good serviceable cloth of English manufacture' and in 1928 it is specifically admitted to be cotton. It was sold in 6 yd rolls up to 74" wide and the price for the 74" width was 21/- per roll compared with 54/- for the best linen. This approximate ratio seems to be the price differential to the present day. Cheapness would seem to have been the main reason for its introduction for use either as a student's or sketching canvas and in general artists today still seem to use cotton until they can afford linen.

In 1907 Rowney and Co offered a 'Students Canvas' that was described as follows: "This canvas is made of half flax and half cotton and has the advantage over all cotton canvas being stronger and not so easily dented". In 1936 two types were available, an openly woven canvas with a cotton warp and flax weft (Quality 'S') and a closely woven canvas with a flax warp and cotton weft (Quality 'V'). Winsor and Newton also introduced a mixed cotton/flax canvas in 1935 (NP Range) specifically prepared "to meet the requirements of students in Art Schools where it is not necessary for imperfections in the raw cloth to be removed by picking before it is prepared". It may have been their closer resemblance to linen that gave these cotton/flax mixtures their appeal. Chemically and mechanically they were not an improvement, and Doerner does in fact warn against them. It is entirely probable that these cotton/linen mixtures may have been used much earlier and more widely than we think especially if we con-

sider the history of the textile industry and its probable influence.

Between 1890-1910, there was a vast expansion in both Britain and France, in the variety of prepared canvases being sold. It was during this time that cotton canvases became widely available, a century after cotton production had become mechanised. It was sold then as a cheap substitute for linen, and it took another 40 years for artists to begin to use it as a fabric with its own intrinsic properties; by which time they generally chose cotton ducks and often the heavier weights. The earliest painting in the Tate Gallery, London on cotton duck is Conroy Maddox's "Passage de l'Opéra", 1940. The next is Jackson Pollock's "Yellow Islands", 1952. Our impression is that while cotton duck was unusual in the 1940s, by the 1950s it was becoming commonplace, especially in America. The usual reasons given for its adoption are the large available widths, its whiteness, absorbency and cost. Although Winsor and Newton listed three qualities of linen available in 126" widths before the war, they were not available afterwards. Whiteness and absorbency were obviously crucial to the 'stain' paintings of Morris Louis and Helen Frankenthaler who began using thinned oil paint on unsized, unprimed cotton duck. Frankenthaler's "Mountains and Sea" (Metropolitan Museum, New York, on loan), 1952 is a seminal example. The previous year she had been painting on unsized, unprimed linen.

A wide variety of other textiles have obviously been used from time to time. Robert Rauschenberg's "Hoarfrost" series employ silk, satin and muslin. The use of silk has a long tradition, at least one example survives from the 14th C. (Parement of Narbonne, Louvre, Paris) as well as works by the 17th C painter Guido Reni. In the 1940s Clyfford Still painted on brown and blue denim, a support which seems as unstable as the blue or black cloths collaged with white that Cennino Cennini describes for wall hangings. Medieval artists also painted clothing, so they would have known how to work on wool or velvet. Velvet continues to be a favourite support for colourful tourist clichés. It emphasises the fact that while almost every fabric has been tried, few of them are entirely new. Those that are new have not been extensively tried yet. If one considers how thoroughly synthetics have replaced natural fabrics in the clothing industry, artists suppliers and artists appear very conservative in this respect. Among the Artists Suppliers known to us Lefranc and Bourgeois (France) are exceptional in marketing a prepared (acrylic ground) polyester non woven 'Polytoile' 15, and Ploton's (London, England) in selling rolls of prepared (acrylic ground) Nylon canvas as well as an unspecified Italian synthetic textile.

Linen and cotton have thus continued to be preferred by artists seeking to paint on stretched fabrics. Given the materials previously available, linen in particular has always been a sensible choice, yet today from the viewpoints of their chemical stability and mechanical properties they are very far from ideal, materials. It is worth considering some of their drawbacks in more detail since this will help to serve as one reference point in assessing new materials.

Strength loss is the most evident problem. Whilst linen and cotton begin their life with much greater strength than is necessary for a painting support, they retain it only for a short period. The cellulose chains of which they are composed suffer degradation lead-

ing to chain scission under the influence of light, moisture and environmental pollutants. The strength loss is rapid and extensive. Tests conducted on samples naturally aged in the Tate Gallery, London revealed that in only 24 years linen canvas samples had declined to practically $1/3$ of their original strength 16. Hardly surprising then that so few canvas paintings survive more than a couple of hundred years without some form of treatment to provide additional structural support. Unlined paintings of more than 300 years of age are so rare as to be almost collectors items. Some of this extensive treatment must of course be attributed to lining having become a standard restoration treatment, though it should be remembered that this is not without a certain basis in the condition of the paintings themselves. It is evident that a large number of 20th century paintings have already been lined after perhaps only 50 years of existence. Such treatments are themselves hazardous operations and tend to impose significant changes on the appearance and handling properties of the painting, especially if considered as a whole object rather than simply the visual image.

Cotton is even less satisfactory than linen. The fibres are 2 to 3 times weaker than equivalent linen fibres and consequently though their rate of deterioration due to light is slower than that of linen 17, low strength values will quickly be reached. These factors are sure to cause immense problems for conservators; fifty years from now entrusted with the care of the large paintings on cotton which are so common in our galleries today.

Just as problematical given the optical role that exposed canvas plays in many modern paintings are the colour changes that accompany the chemical degradation. Significant darkening and yellowing of the surface take place very rapidly. The 24 year old linen samples from the Tate Gallery showed a decrease in reflectance of 10% at the red end of the spectrum and 50% at the blue end of the spectrum 16.

Again cotton is known to change colour more rapidly than linen and since its natural cream white colour has often been utilised by artists such a change will completely alter the tonal relationships within the painting. The original intention of an artist such as Morris Louis or Helen Frankenthaler will be irretrievably lost.

But more subtle problems also exist. Linen and cotton are moisture sensitive supports. The moisture regain at 65% RH of linen and cotton is taken as 12% and 8.5% respectively. They swell and shrink differentially from other layers in the painting and their mechanical properties also change. This process in the painting as a whole can lead to powerful shear and tensile stresses being set up and to cracking and delamination. Cotton can imbibe as much as 40% moisture at 100% RH and appears to respond more rapidly to moisture changes. It has been observed that large paintings on cotton are particularly prone to fluctuations between very slack and very taut states. This affinity for moisture also leads to soiling of the cotton and linen supports.

Woven fabrics in general and cotton and linen in particular do not have ideal mechanical properties when considered for use as a painting support. What is required is a material which becomes taut under the minimum of applied strain, which does not subsequently re-

lax and which has the same properties in all directions. This requires a material of high initial Youngs Modulus (and low elongation) resistant to stress relaxation and creep and exhibiting isotropic behaviour. Cotton and linen fail on all these counts when considered in the woven form. These problems are increased when the whole stretching process is considered.

Given this well established catalogue of drawbacks it is perhaps surprising that more attention has not been paid to developing new painting supports. Among the reasons for this may be the facts that conservators have not played a prominent role in developing artists materials, and that most artists suppliers are primarily manufacturers of paint, who only act as retailers for canvas that is purchased from other specialised suppliers, whose reputation rests on the traditional excellence of their product. So, it is an area of research and development in which conservators have a special role to play, not only in their capacity to offer advice but because the criteria for the most durable and stable painting support are the same as those for the most durable and stable lining canvas.

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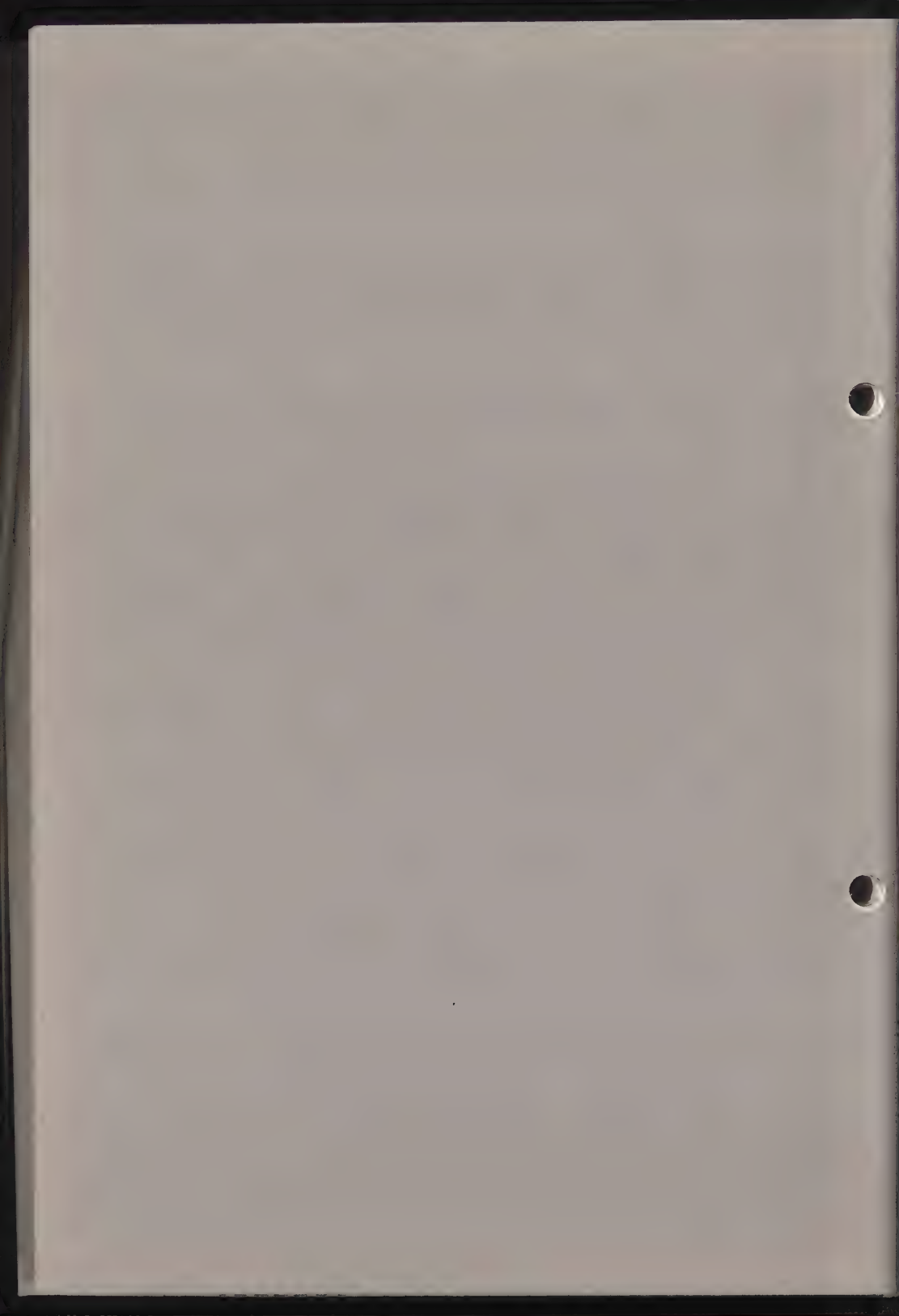
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THE STIFFNESS OF LINING FABRICS: THEORETICAL
AND PRACTICAL CONSIDERATIONS

Gerry Hedley

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Structural Restoration of
Canvas Paintings



THE STIFFNESS OF LINING FABRICS: THEORETICAL AND PRACTICAL CONSIDERATIONS

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Abstract

The meaning and necessity of stiffness in lining supports are discussed from a theoretical viewpoint. Ten desirable properties of lining fabrics are defined and a survey of synthetic fibres is made. Glass fibre and polyester fabrics are considered to be the most suitable materials. A range of these are tested for stiffness, and the results reported. Significant amongst these are the existence of high extensions in the bias direction for fibre glass fabrics. Attention is drawn to polyester sail cloth materials, which performed well in the tests. These are specially woven to achieve relatively high stiffness in all fabric directions.

INTRODUCTION

This paper will address itself to an important problem in painting conservation, that of minimising the applied strains and hence the stresses in lined paintings. The most effective way to do this is, of course, to utilise a rigid support. There are though significant objections to this practice of marouflage. First it fundamentally changes the nature of the object, secondly it presents considerable practical problems both in bonding and reversibility. Weight and subsequent impact damage are also drawbacks. Despite this, the method has found application and from the viewpoint of mechanics it is an admirable way of preserving the art work. The aesthetic drawbacks of the technique will though mean it is unlikely to be extensively utilised.

The question therefore arises as to whether it is possible to achieve in a support most of the benefits of rigidity whilst retaining a certain degree of flexibility, and thereby not altering

the basic nature of a canvas painting.

Some success has been achieved in this area by utilising glass Fibre Fabrics, sometimes with coatings applied.^{1, 2} It is the purpose of this paper to consider the mechanical requirements of stiffness (or rigidity) in lining supports and to provide some basic data on the performance of the most suitable types of fabric.

It is not difficult to specify the desired parameters for a lining support it must have:-

1. excellent durability, resistance to acidic pollutants and light
2. high stiffness (Young's Modulus), hence low extensibility
3. isotropic behaviour
4. good elastic recovery
5. resistance to creep and stress relaxation
6. negligible hygroscopicity
7. good bonding to lining adhesives
8. acceptable aesthetic properties
9. acceptable handling properties, availability
10. minimal surface texture

SYNTHETIC FIBRES

Evidently linen canvas is unable to meet the criteria from 1-6 and need be considered no further.³ It is therefore worth surveying the available synthetic fibres to see to what extent they might be suitable.

Kevlar a polyaramid fibre has been especially manufactured as a high stiffness and high strength material and thus would appear to have very desirable mechanical properties. Indeed it has been used together with hemp in a lining canvas prepared in Italy.⁴ However, Kevlar deteriorates rapidly under the action of light. It can lose 50% of its strength in 50 hours of exposure to sunlight. Its durability is therefore rather suspect and its colour (gold) may also be a drawback.

Polypropylene Fibres are the lightest of all Fibres, their specific gravity is only 0.91 compared to Flax which is 1.50, and might therefore warrant consideration. The Fabrics can also be obtained in a form which is very similar to that of cotton duck. Their tenacity of up to 8 gm/denier 20⁵ is superior to linen (2.6 - 7.7 gm/den) and it is unaffected when wet. Indeed polypropylene is so non-absorbent to moisture that its moisture regain value is zero as is that of glass. At 65% RH it contains no moisture whereas cotton has 8.5% and linen 12% regain.

Regrettably polypropylene has major drawbacks. It is extremely vulnerable to deterioration by light, some reports suggest even more so than flax 15⁶. It is also a fibre which tends to have high elongation and low initial modulus. Typically it can extend 18% at break compared to 9% for a similar tenacity polyester. Neither is its elastic recovery complete, being of the order of 90% after a 5% strain (including delayed recovery). This compares favourably with cotton which is only 70-75%, but polypropylene also tends to creep³. This is a serious problem. A Fibre will extend 0.5% in 16 hours under a load of 1.5 gm/denier. As a result polypropylene

canvas may well be expected to slacken on a stretcher. Bearing in mind these properties polypropylene Fabrics would not appear to be the most suitable alternative to linen despite their lack of response to moisture. Polyvinyl alcohol fibres have the disadvantages of being moisture responsive and susceptible to creep. They could tend to become slack in a similar way to linen or polypropylene over a prolonged period of time. Acrylic fibres have good durability, but they tend to have lower tenacities than do flax and cotton, this combined with their high elongations under loading would seem to make them inappropriate unless stabilised by some form of impregnation.

Glass Fibres have much to commend them mechanically and chemically. They are extremely strong and possess a high modulus in tension. They exhibit negligible creep³. They do not absorb moisture at all (though their tenacity is reduced when wet). They are affected by light and gradually lose strength, though the rate at which they do so is reduced with time. They resist attack by environmental pollutants and have very low cost. These beneficial parameters have led to their use as lining supports. There are, however, significant problems. The first is that stiffness in a fibre does not necessarily mean that this is translated into stiffness in a fabric. Indeed, glass fibre fabrics are often relatively loosely woven and as we shall see, exhibit a high degree of anisotropy in their load extension-curves. The second problem is their general handling behaviour. The problems of using glass fabrics are so well known that it is not necessary to elaborate this point. A further difficulty lies in their lack of abrasion resistance, this means that they are effectively most vulnerable at the turn over edges of paintings. This unfortunately is also the region of greatest loading. Finally, many conservators find the appearance of glass fabrics to be rather unsympathetic.

These drawbacks can be minimised. One of the most effective ways of doing this is to pre-coat the fabric with a resin. Teflon coated fibre glass is an example of such a treatment and will improve the behaviour of the fabric, though at the expense of a certain flexibility.² Conservators may also attempt to resolve the problem by impregnating the fabric with the lining adhesive or with another resin.¹³ These are acceptable solutions, but they are only necessary because of the basic lack of isotropic stiffness of the woven fabric.

Nylon has high strength and excellent elastic recovery, but its long term stability to light and acidic pollutants is not good. It also absorbs moisture (4-5% at 65% RH) and has an unpleasant appearance.

Polyester (polyethylene terephthalate) fibres have much to recommend them. The fibres are fairly stiff, they have tenacity and their elastic recovery, though not as good as nylon, is better than polypropylene. They will withstand 3% strain without any permanent set occurring. Moisture absorption is extremely low, typically around 0.4% at 65% RH. They will imbibe only 2% moisture when maintained at 100% RH.⁵ At low extensions they resist creep and are characterised by a fairly high initial modulus of 100-130 gm/denier. Polyesters have good abrasion resistance, are absolutely resistant to mildew and have good resistance to sunlight. Their deterioration

is further reduced if UV is excluded. Indeed in these circumstances certain polyesters can be superior to the acrylics.⁶ They are extremely resistant to acids.

MECHANICAL CONSIDERATIONS

The most suitable fibres for lining supports therefore appear to be glass and polyester. However, good mechanical properties in Fibres are not necessarily translated into Fabrics woven from those fibres.

There are two major mechanical weaknesses evident in woven fabrics if we wish to use them as lining supports:

1. The nature of a woven fabric in which one yarn intertwines over another produces a lack of stiffness when initially stretched. This is because the extension is due to a straightening or decrimping of the yarns, and not due to their elongation. Woven fabrics therefore generally have an initial low modulus region to their extension curve. Linen fabrics normally show this defect.^{3, 7} This is why it is very sound practice to pre-stretch fabrics before using them in lining. This approach is particularly rigorously applied in Italian practice.
2. Woven fabrics are extremely anisotropic, they extend differently along the weft and warp, and very much more if pulled at angles diagonal to the weaving directions.⁷ They will thus impose anisotropic strains on the painting, and not behave as a linear support.

It is important to look at stiffness or resistance to extension in more detail in order to see why without high stiffness, a material should not be considered as a suitable lining support.

The stiffness of an elastic material is a measure of how much it will extend under a given applied load. Thus a material of high stiffness will hardly extend at all under a particular load, whereas one of low stiffness will show considerable elongation under the same load. We can illustrate stiffness by use of a graph, Figure 1, which plots strain, a measure of the extension of a material, against stress, a measure of the applied load. The stiffness or Young's Modulus of an elastic material is defined as the gradient of the graph, it is the ratio of applied stress to generated strain. The stiffer the material involved, the steeper will be the curve, so that in Figure 1 material A can be seen to be stiffer than material B. It is clear that under a stress of S, A would extend only x units, whereas material B would extend the much greater amount denoted by y.

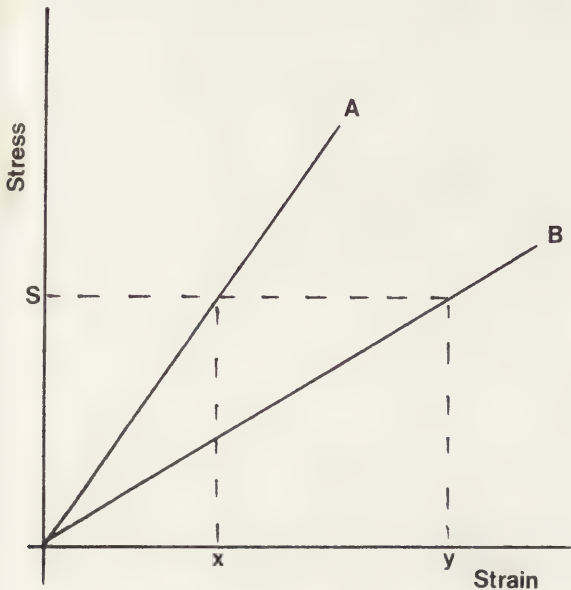


Figure 1. A graph of stress plotted against strain showing two materials of different stiffness.

Now when a painting is lined to an auxillary support and subsequently stretched, it would make engineering sense to utilise the stiffest possible support.

When we stretch a lined painting we usually do so to achieve a reasonably taut effect. This 'tautness' is really the effect of the material attempting to contract back to its original size. It is an indication of the stress within the material. Thus referring to figure 1 again, in order to achieve a stress of S in material A, we would need to strain it only x units, whereas to get the same stress in B, we would have to strain it by the larger amount of y . So a stiffer material will become taut (and we will therefore stop stretching it) at much lower applied strains.

This is very important when the interaction with the painting composite* is also considered. It is clear that we have much to gain by imposing the least possible

* For simplicity the painting composite of paint, ground and canvas is assumed here to have one effective stiffness, in reality each layer has differing Young's Moduli.

strains onto the painting. Figure 2 serves to illustrate this point.

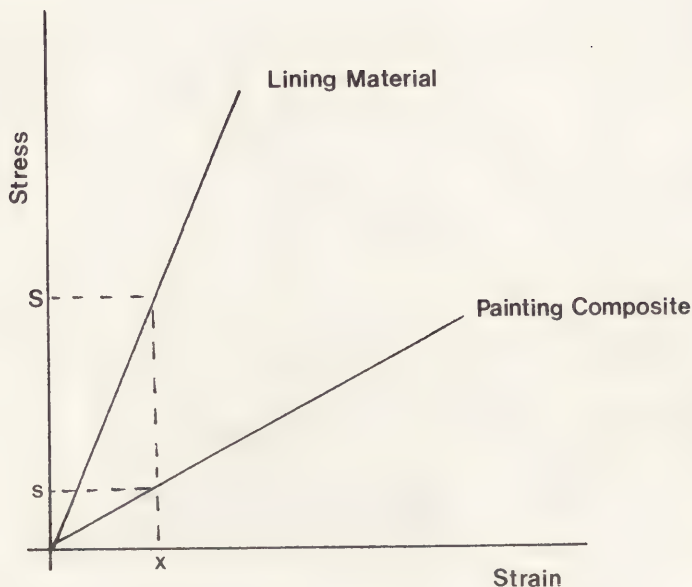


Figure 2 The interaction between a lined painting and a stiffer lining support.

It shows the situation in which a stiff lining material is used bonded to a less stiff painting composite. Here we can see that if the lining material has been stretched to produce a stress of S , the stress at that extension x , induced in the painting layers will be the very much lower s .

It should also be evident that if an even stiffer lining material had been chosen, then the stress induced in the painting layers would have been still smaller. More disturbingly Figure 3 shows what would happen if a lining material of low stiffness were chosen. In this case if the lining and painting were stretched to produce a tension of S in one of the layers that tension would be in the painting layers. The stress in the lining material would be very much less (e in the diagram). We would thus have created a situation in which the high stress was carried by the painting and the low stress by the lining material. In fact the painting would be acting as a support for the lining!

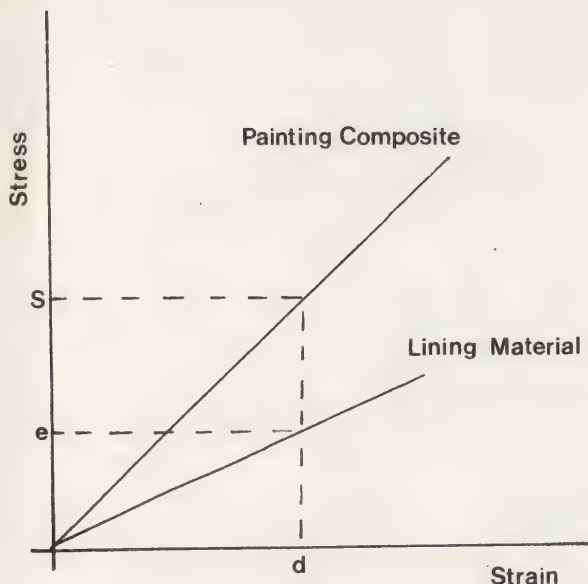


Figure 3 The interaction between a lined painting and a less stiff lining support

There is one final reason why we should consider stiffness as an essential property of a lining material. Mecklenberg⁸ has shown that the materials which make up a painting do not have constant mechanical properties, they change as the relative humidity alters. Glue size, for instance, changes from being a material of low stiffness to one of high stiffness as the RH falls. Figure 4 shows this effect. What this also means is that since the strain in the material will have remained the same e.g. y , the stress in the material, its tension will have dramatically increased from a low S_1 to a high S_2 . Mecklenberg has suggested that this may be a fundamental cause of cracking in paintings. If this is so, it is obviously very important to minimise the value of the strain which we cause in the painting. For instance, if a strain of only x had been present, then the stress in the dry state would have been not S_2 , but the very much lower S_3 . Consequently, we must seek to impose the minimum of applied strain to the painting layers if we are to avoid high stress build up as the RH varies. This can be done by utilising a lining material of high stiffness.

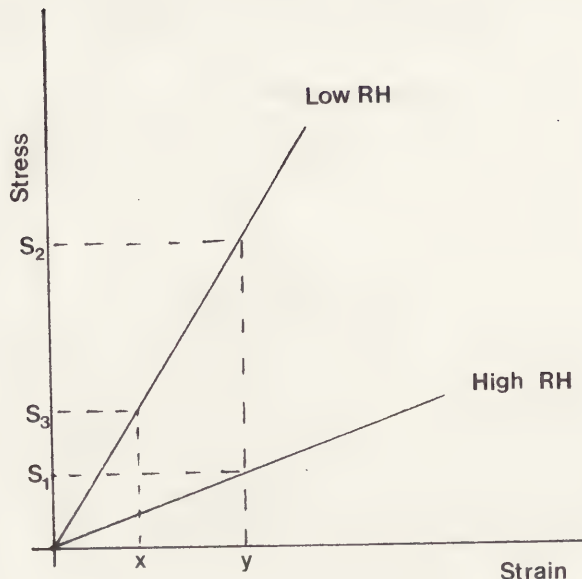


Figure 4 The importance of low strain values in gelatine, a material which increases its stiffness when the Relative Humidity drops.

A further corollary of employing a high stiffness support is that much less problem is likely to be encountered with the 'lifting of torn areas, since the stress developing an out of plane alignment will be greatly reduced. It should also be added that high adhesive strength also becomes less critical, though conservators might be well advised to work within a healthy safety margin.

STIFFNESS MEASUREMENTS

Since polyester and glass fibres appeared to have the best overall properties, it was decided to investigate the stiffness of a range of fabrics in these materials.

The tests were conducted on an Instron 1026 Tensile Testing Machine using mostly samples 6" long and 1" wide. The samples were stretched separately in the weft and warp directions up to a maximum loading of 20 kg.⁹ Those fabrics which performed well in these tests were also tested at the 45° bias angle.

Table 1 shows the results obtained. The stiffness of the fab-

TABLE 1 ELONGATION DATA

No.	FABRIC Plain weave	WEIGHT oz./yd. ²	THICK- NESS cms.	COUNT WEFT WARP ends/in	PERCENTAGE ELONGATION							
					2kg. Load		4kg. Load		10kg. Load		BIAS	BIAS
					WEFT	WARP	WEFT	WARP	WEFT	WARP		
1	Fibre glass A	3.0	0.009	58 58	0.59	0.66	16.4	0.72	0.92	1.22	17.7	Failed
2	Fibre glass B	5.8	0.016	32 44	0.19	0.34	20.7	0.34	0.72	1.04	Failed	Failed
3	Fibre glass C	5.6	0.016	33 37	0.82	1.31	26.4	1.02	1.91	1.38	Failed	Failed
4	Fibre glass D	8.9	0.024	26 30	0.66	1.31	26 Failed	0.95	1.04	1.21	Failed	Failed
5	Teflon Coated Fibre glass*	13.2	0.035	22 33	0.33	0.63	12.1	0.66	1.31	1.35	18.5	Failed
6	Polyester A	7.1	0.035	54 71	1.6	1.6	-	3.0	2.3	6.0	-	-
7	Polyester B	6.5	0.04	38 43	2.6	1.3	-	3.6	2.6	6.6	-	-
8	Polyester C	5.2	0.027	54 68	5.9	2.0	-	7.7	3.0	11.0	-	-

TABLE 1 Continued

No.	FABRIC Plain weave	WEIGHT oz./yd ²	THICK- NESS cms	COUNT WEFT WARP end/in	PERCENTAGE ELONGATION											
					2kg. Load				4kg. Load				10kg. Load			
					WEFT	WARP	BIAS		WEFT	WARP	BIAS		WEFT	WARP	BIAS	
9	Polyester D	6.2	0.031	38 38	3.4	1.3	-		4.6	2.0	-		6.9	3.1	-	
10	Pure sailcloth polyester	8.0	0.30	68 117	0.36	0.97	2.02		0.97	1.55	3.71		2.54	3.02	9.02	
11	Impregnated sail polyester	8.0	0.30	68 117	0.29	0.57	0.70		0.63	0.96	1.64		1.94	2.10	5.4	
12	Tencate (poly vinyl alcohol)	6.0	0.035	63 90	1.05	1.31	4.36		2.20	2.69	8.14		4.53	7.48	15.6	
13	Oil primed linen	13.4 Primed	0.045 Primed	38 44	0.16	Minimal	0.16		0.33	Minimal	0.33		1.64	0.26	0.98	
14	Acrylic primed linen	12.2	0.075	28 28	1.6	2.6	-		3.6	7.2	-		5.3	13.5	-	

*Results for this material should be regarded as provisional (see text)

rics can be assessed by considering the tabulated extensions at 2 kg, 4 kg and 10 kg. The two lowest loads being representative of the sort of force which might be applied during stretching. A high extension is indicative of a material of low stiffness and vice versa.

The results for the fibre glass fabrics are particularly interesting. As can be seen they all exhibit very high stiffness in the weft and warp directions. What is more, the extensions in these directions are similar, so they are close to isotropy in the two weaving directions. This is a reflection of the high stiffness of glass fibres.

The bias direction is dramatically different. Here very large extensions develop under tiny loads. Some of the materials could not stand 2 kg of load in this direction, without beginning to pull apart. It is the loosely woven character of most glass fibre fabrics which leads to this behaviour and it is something which is readily felt when handling the fabrics. This would be considerably modified under biaxial loading such as is encountered in stretching a painting, but it is still a cause for concern. More especially so as it is known that during stretching (and subsequently) the largest stresses (principal stresses) are at certain points generated in the bias direction. This is, for instance, the case at the corners. Rigidity in this direction should therefore also be sought.

Impregnation may help to improve the situation, but is usually only really effective at very low strains. The Teflon Coated Fibre Glass supplied with adhesive by Fieux was a marked improvement over the pure glass fabrics, but it too exhibited a noticeable degree of anisotropy in the bias direction. The exact values obtained for this material are provisional since 2.4 inch samples were used.

These reservations aside, glass fabrics should be regarded as having good mechanical stiffness properties compared to the vast majority of other fabrics and though not ideal, they are worthy of use as lining supports.

The results obtained for the polyester fabrics are best considered in two groups. The first being those which are conventionally woven. This includes fabrics Nos 6, 7, 8 and 9. As can be seen from Table 1, these Fabrics have nothing like the stiffness in the weft and warp that was found in the glass fabrics. What is more, there are quite large differences between the extensions undergone in the two directions.

In general, this group of materials is comparable to linen and some other conventionally woven synthetic cloths. Their superior properties in regard to stress relaxation and moisture response would make them a better choice within such a comparison. However, they do not have the same qualities of high weft and warp stiffness that glass Fabrics have.

The second group of Fabrics is of special importance. It comprises materials Nos 10 and 11. These are specially woven monofilament polyester fabrics produced for use as sails. 10 It so happens that the mechanical requirements of sails are closely similar to those which we require in a lining support, i.e. high stiffness and isotropy. They have therefore been woven and subsequently treated to produce these properties. Material No 10 is in its pure state with no additives and Material No 11

has been impregnated with a melamine formaldehyde resin.

Referring to Table 1, it can be seen that these materials exhibit very high stiffness in the weft and warp directions and are fairly isotropic. The degree of stiffness is of the same order, though not quite so good as that obtained with glass fabrics. Still more importantly the bias direction is also quite stiff and is vastly superior to that of the glass fabrics. The polyester sail cloths therefore combine high stiffness and isotropy to a degree not encountered in other materials tested.

The main reasons for this are the extremely close weave and a subsequent heat set treatment which locks the weave. The impregnation with a melamine-formaldehyde resin still further improves the mechanical properties, but is probably not the best choice for conservation use.

The fact that sail makers choose to use polyester fabrics is of some significance to conservation in that they also regard durability and resistance to light degradation as being very important.

Sail cloths are available normally in widths of only 91 cms, but we have also been able to obtain from one weaver a cloth which is larger than 2 metres ¹¹ (adequate for most linings).

Samples of the materials will be available at the Conference. They combine high stiffness with very good flexibility (especially in the pure state) and are woven to extremely high standards. Material No 10 for instance is allowed only 4 weaving faults per 100 metres, and the surface is extremely smooth and even. Because of this bonding with wax is not very satisfactory, but we have obtained good bonds with cold lining adhesives and with BEVA. The handling and abrasion resistance of these fabrics are very good.

Tests are being conducted on a wider range of sail cloth fabrics both in regard to stiffness and bonding techniques, and further results should be available at the Conference.

The Material No 12 Tencate is also listed in this group, since it is a material woven to similar specifications as the sail cloth. This polyvinyl alcohol Fabric shows good stiffness in all three directions, but it does not perform as well as the sail cloths. Its handling is good, though moisture responsivity and creep are problems associated with this polymer.

Attention is drawn to the data recorded for two primed linen canvas samples. These show both high stiffness and a high degree of isotropic response primarily because of the weave locking effect of the ground. This data is further evidence of the importance of the search for these mechanical properties in lining supports.

Fabric supports are not the only materials which might be considered 12, 13, but they do have a closeness to the original nature of the work which is important to many. If they are to be utilised the data and observations in this paper suggest that stabilised glass Fabrics and sail cloth polyesters most closely meet our chemical and mechanical requirements.

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9. The tests were conducted at a rate of extension of 5mm/min
10. I am indebted to Marion Mecklenberg, as keen sailor, who drew my attention to the properties of sails in Ottawa in July 1980
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81/2/3

THE ROLE OF TENSION IN THE PRESERVATION
OF CANVAS PAINTINGS: A STUDY OF PANORAMAS

Gustav A. Berger

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Structural Restoration of
Canvas Paintings



THE ROLE OF TENSION IN THE PRESERVATION OF CANVAS PAINTINGS:
A STUDY OF PANORAMAS

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Abstract: Cyclorama paintings, usually 15x125 meters in size, provide a unique source of homogeneous information in a quantity that becomes immediately statistically valid.

Examination of six cycloramas so far (total area about 10,000m²), has shown that steady low tension of ca.600g/cm effectively prevents cracking and distortion of canvas paintings, even in the absence of climate control. In contrast, rigid stretchers seem to be detrimental to the preservation of large canvas paintings.

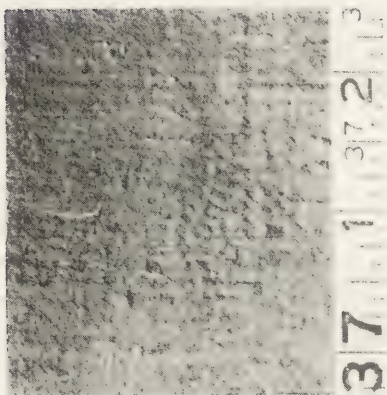
When asked in 1978 to submit a proposal for the conservation of the Atlanta Cyclorama, I seriously began collecting all available information on the subject. My previous research on painting consolidation had made me painfully aware of the lack of hard data about the behavior of paintings. In most cases, determining their actual composition, technique and construction is a matter of conjecture, and their physical history is largely unknown. Consequently, any conclusion about the causes of their decay becomes no more than a guess. To my surprise, cyclorama paintings have proved to be a welcome exception. They are capable of providing valuable data on the physical behavior of oil paintings supplying an almost unlimited number of observations on the conditions of the canvas and paint film. The overwhelming quantity of the information can be statistically evaluated to any desired confidence level.

Cycloramas are huge, nearly cylindrical oil paintings, usually 15x125 meters in size. When originally painted, they were made and exhibited in buildings of circus-like proportions(1). Strips of heavy Belgian canvas, ca.7-8 meters wide, were sewn together either vertically or laterally, to form sheets over 60m long. Typically, two

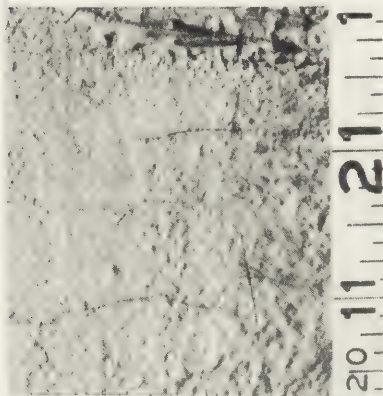
FIG.1 TYPICAL CRACKLE PATTERN AT DIFFERENT LEVELS
OF THE ATLANTA AND GETTYSBURG PAINTINGS

ATLANTA CYCLORAMA

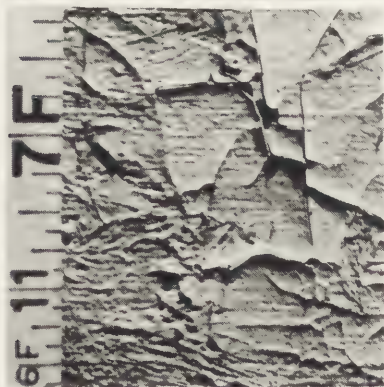
GETTYSBURG CYCLORAMA



11.3m



6.4m



2.1m

TOP LEVEL DESTROYED

(Photographs from:
W.J.Nitkiewicz, "Treatment
of the Gettysburg Cyclorama",
Studies in Conservation,
Vol.10, No.3, 1965)

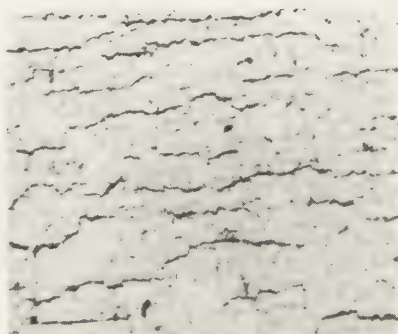


FIG. 5. Type of crackle in upper levels of paintings

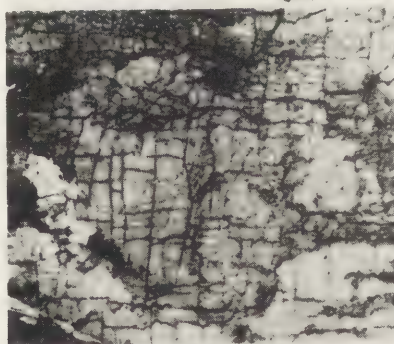


FIG. 6. Type of crackle in lower levels of paintings

such sheets would be used per painting. They were nailed to a wooden beam supported by the roof trusses or by the workshop walls. Sail makers sewed the remaining vertical seams together, where the enormous sheets met. They were stretched vertically by their own weight and sometimes by added ballast in the form of bricks or an iron ring(2).

If we consider the average size of an oil painting to be approximately 55x90cm, then one cyclorama has the area equivalent to 3000-4000 paintings. Examination of six hanging cycloramas yielded information comparable to that of approximately 20,000 paintings. This inspection has shown that, without exception, all the cyclorama paintings have cracked and deteriorated very little, especially at the top where they are under constant tension (Fig.1). Considering the fact that some cycloramas are subject to extreme changes in temperature and humidity, it seems that valuable information was gained which might lead to improvements in the treatment of canvas paintings(3,4).

Cycloramas are exposed to the most extreme variations of temperature and humidity (Fig.2). Under such conditions, even the most technically perfect paintings would be expected to deteriorate rapidly. Cycloramas, however, are in much better condition than easel paintings of the same period and school. This is exemplified by the Mesdag Panorama, which is in overall excellent condition, showing few cracks over its entire 1800m² surface. Mesdag himself, believing that his painting would last no more than twenty five years, did not paint it for posterity, and may not have been overly cautious in its execution. In addition, some sections of this cyclorama are exposed to direct sunlight, without any temperature/humidity control, for a hundred years, and have nevertheless failed to produce the usual cracking, distortion, or delamination. Mesdag's smaller, 'serious' paintings, are displayed in the museum adjoining the panorama building. In spite of the infinitely better care these paintings have received, both in their execution by the artist and in their display and storage by the curatorial staff of the Mesdag Museum, they show cracking and decay, typical of 100-year-old paintings.

One might attribute the good condition of the Mesdag Panorama to the mild and humid Holland weather which is especially kind to oil paintings. This is not the case, however, in the Jerusalem Cyclorama in St. Anne de Beaupré,

FIG. 2 FLUCTUATIONS IN RELATIVE HUMIDITY OF THE ATLANTA CYCLOPAMA



R.H. at the top of the painting ———

R.H. at the bottom of the painting - - -

November 24-29, 1980

November 24-29, 1980

near Quebec; The painting is exhibited in a building whose only means of climate control is a type of chimney topped by an exhaust fan. Inside the building, temperatures fluctuate to extremes, and once or twice yearly the floor of the building is flooded, raising the humidity to such a degree that the painting's Damar varnish blooms for several weeks after. In addition, the roof caved in during a snow storm (as also happened to the Atlanta Cyclorama) destroying about one third of the painting. The roof was not repaired for several months, and the painting exposed to the ravages of the Quebec winter. Such treatment would surely have destroyed any conventional painting. Yet the St. Anne Cyclorama is still in near-perfect condition, with no disturbing cracks in its upper parts. It shows only shrinkage cracks in the dark colors in the lower part of the painting, which is probably due to inferior paint composition (a combination of dryer and asphalt?).

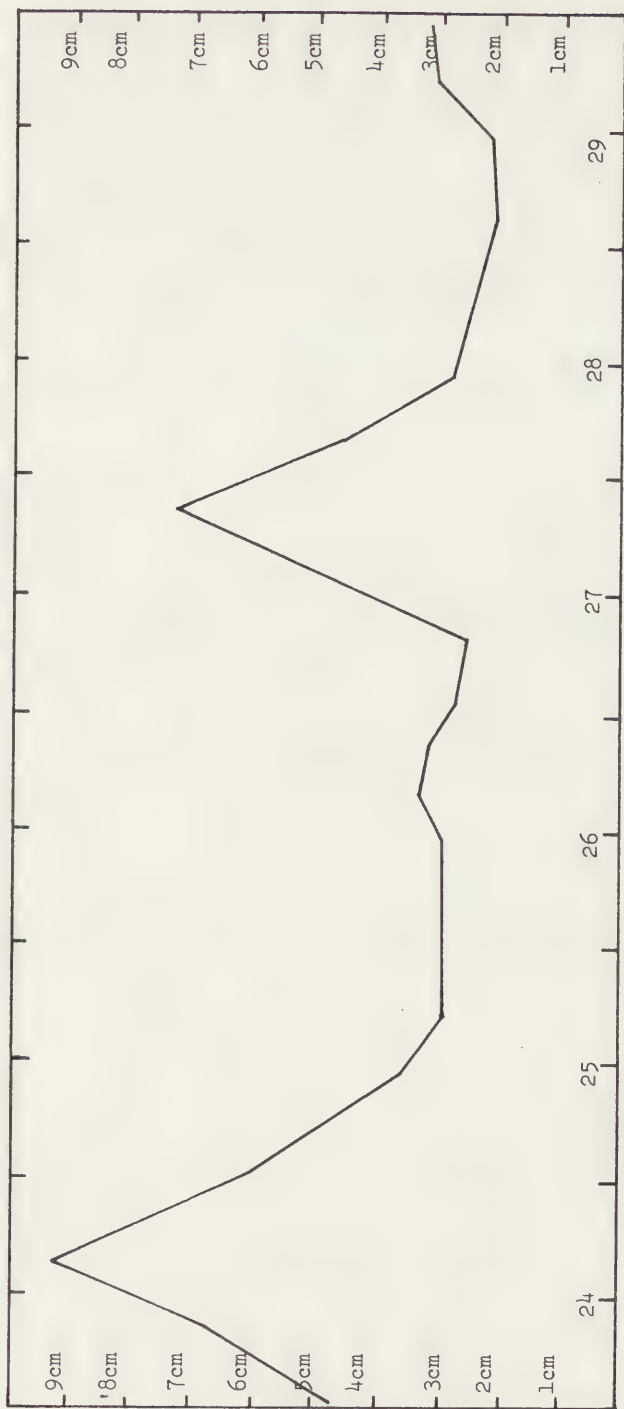
What are the reasons for the excellent state of preservation of the paint film in cyclorama paintings? In my previous report to ICOM I have described the conditions leading to distortions and cracking of paint films(5). Rupture and distortion of paint films are a direct result of dimensional changes of either the film or the substrate. Such dimensional changes have to be both rapid and significant to overcome the natural plasticity and elasticity of the paint film. These dimensional changes are caused by a number of outside factors: Shrinkage of the paint film due to oxidation and polymerization is one of them; impact, shrinkage or expansion of the substrate due to changes in temperature and relative humidity are others, and there are many more, too numerous to list here. Paint films show clearly that if one of these stress factors is suppressed, the result is a considerable improvement in the preservation of the film. For example, where a paint film is protected from light by the rabbet of the frame, cracking is markedly reduced and sometimes non-existent. A similar improvement can be noted where a painting is protected from the back by the stretcher bars, or a patch. The above observations have led to improvements in the preservation of paintings. Since the external factors leading to cracking of paint films are all acting on cyclorama paintings, there must be some inner mechanism, not present in easel paintings, which protects cycloramas from the usual decay of their contemporaries, and which keeps the upper parts of these paintings in better shape than their lower parts. Since they are made in the same way and from the same materials as other oil paintings of the same period, it must be the unique suspension system of cycloramas and the type of tension it generates which should be credited with their exceptionally good state of preservation.

The cyclorama painting is suspended only at its top edge from a rigid wooden ring which may be considered practically free from expansion and contraction movements. The canvas is simply nailed to the ring without stretching. The weight of 15 meters of painted canvas exerts a tension of about 500-700 grams per centimeter which is comparable to a lightly stretched canvas. That the stress is not excessive is evidenced by the fact that after a hundred years, the Atlanta Cyclorama tore only in one spot, just where the free flow of the canvas was impeded by the wooden uprights holding the main seam. The Mesdag Panorama is hanging freely, and has no tears at all.

The force which stretches a free-hanging cyclorama is the vertical pull of gravity exerted by the weight of the painting. If canvas is stretched, it contracts at right angles to the direction of the pull. In the case of a hanging painting, the vertical pull of gravity causes the canvas to narrow laterally. In a cyclorama, the free-hanging canvas closes on itself. Therefore lateral contraction also returns on itself, and is automatically transformed into lateral stress which keeps the canvas taut at all times. The lateral contraction leads to a gradual reduction of the circumference, thereby shortening the radius of the painting and narrowing its 'waistline'. Under the stress of gravity, the cyclorama becomes a hyperboloid, a form familiar to us from the cooling towers of nuclear power plants. This is the natural form an elastic skin assumes when suspended from a ring. Each point on such a skin is pulled downward by the weight of the material suspended below it. This weight, of course, is diminished on the lower part of the painting. The stress exerted by the weight of the canvas is counteracted by its elastic resistance to deformation. Since the weight of the painting is fairly constant, not counting slight changes due to variations in relative humidity, the stress on each point of a cyclorama must also be fairly constant. This is in sharp contrast to paintings on stretchers, where expansion or contraction of the canvas create enormous changes in stress, sometimes leading to actual compression of the paint film.

Research conducted by Dr. Tassinari has shown that an increase of 50% in R.H. (a common occurrence in the day of a cyclorama) causes the canvas to expand by more than 1% (6). A still more rapid contraction can occur when the R.H. approaches 90%. When canvas on a rigid stretcher shrinks by 1%, a force is exerted by the stretcher sufficiently strong to elongate the canvas by the same 1% by

FIG. 3 FLUCTUATION OF CANVAS DIMENSIONS IN THE ATLANTA CYCLORAMA
Shrinkage of the canvas during November 24-29, 1980



Vertical shrinkage as measured from the top of the cyclorama to an arbitrary line on the canvas, 12.4 meters below the top edge (marked 3cm on the diagram). Note that maximum shrinkage occurs at 100% R.H. (See Fig. 2)

which it has shrunk. Using Tassinari's figures, 2000 to 3000 grams per centimeter are needed to cause an elongation of 1%, depending on the type of canvas(7). That means the stress exerted by the shrinkage of canvas mounted on a rigid stretcher is much larger than the stress exerted by the weight of 15 meters of heavily painted canvas at the top edge(700g as compared to 3000g). In other words, the stress exerted by shrinking canvas is four or five times greater than the weight of 15 meters of painted canvas. Even today, after a 100 years of expansions and contractions, the canvas of the Atlanta Cyclorama fluctuates in size. From November 10th to November 24th, 1980, the height dimension of the canvas shrunk by 68mm. From November 24th to December 12th, 1980, it grew by 77mm. Fluctuations of 50mm within one day are routine (Fig.3).

It is easy to understand that the comparatively low but constant tension at the top edge of a cyclorama is less stressful to the painting than repeated fluctuations in tensions caused by a rigid stretcher. On the other hand, the evidence supplied by cyclorama paintings seems to show that the rather mild stretching by weight of 15m of canvas seems to have been sufficient to counteract the distortions caused by the shrinkage of the paint layer. This beneficiary effect of tension is noticeable up to the 7-meter level. At this height the tension is only 250g/cm. It seems to be barely sufficient to immobilize the canvas and counteract the forces exerted by the shrinkage of the paint. Below this level, cracking and distortions begin. At the 3-meter level cracking and distortions are pronounced.

Investigations conducted by the Central Research Laboratory on the Mesdag Panorama, as well as our own research on cycloramas show that the canvas seems to decay faster when under stress. Measurements of the Mesdag Panorama show the canvas at the top to be ca.60% weaker than along its bottom(8). This coincides with our own observations on easel paintings which are generally weaker and more brittle along their edges. If canvas conservation were our prime concern, we would be well advised to prevent its being overstretched by rigid stretchers, and to use spring-loaded stretchers instead. The other alternative would be to use rigid supports with all their innate problems, such as:

- 1) tensions between panel and canvas,
- 2) tensions within the rigid panel,
- 3) repairs more complicated than on canvas supports,
- 4) difficulties in mounting and transportation.

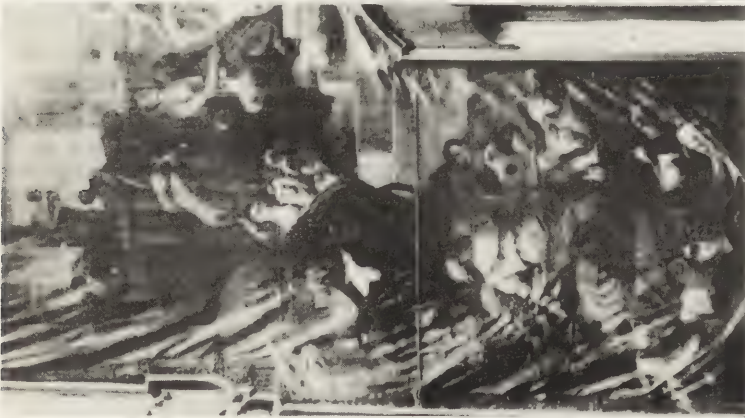


Fig. 4

Sagging & curtain folds,
Italian Baroque painting
(Courtesy, F. Rigamonti)

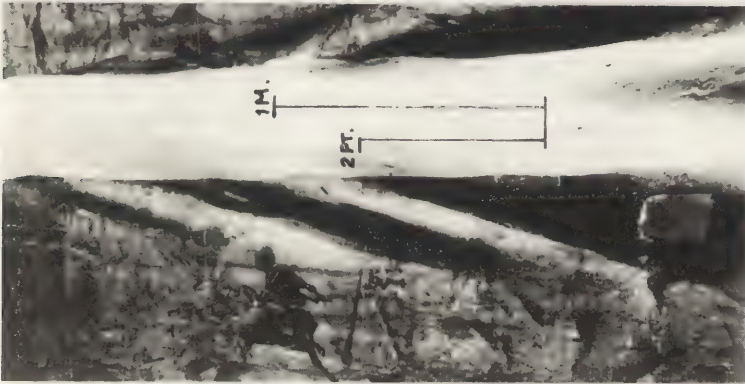


Fig. 5

Curtain folds due
to fiberglass
'facing'

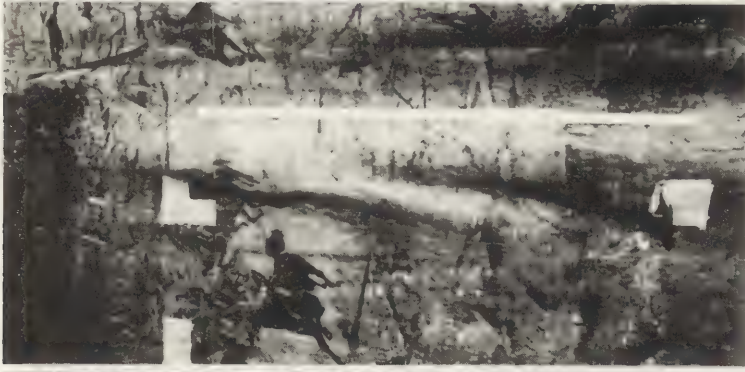


Fig. 6

After removal of the
'facing', the folds
disappear



Fig. 7

Ripple caused
by epoxy bridge-
ing of the seam

However, the combined effect of the stress of a rigid stretcher, and the weight of a large canvas easily exceeds the limits of elasticity of any canvas, it over-stretches it and produces an increase in size (Fig.4). The typical sagging and curtain folds of large paintings develop. There is a continuous stress along the vertical stretcher bars, where the free movements of the canvas are arrested. The tear in the Atlanta Cyclorama developed along the vertical uprights holding the main seam and in the top edge adjacent to it. Curtain folds take only a few weeks to develop, as we have learned from the Atlanta experience. The vertical seams were temporarily secured with fiberglass fabric prior to lowering the painting. A mixture of Beva D-8 emulsion and starch paste was used to adhere the fiberglass facing to the seams. This was done in February 1980 when it was quite cold, and the Cyclorama had shrunk. Since fiberglass does neither shrink nor expand, it impeded the free flow of the canvas in the area it covered, and the same curtain folds of sagging canvas developed as had been caused by the above mentioned wooden uprights. As soon as the R.H. and the watercontent of the canvas increased in July, the folds disappeared soon after removal of the facing (Fig. 5 and 6).

This demonstrates another advantage gained from observation of cyclorama paintings: any effect of an intervention in the movement of the canvas is enormously magnified by the large size of the painting, about 100 times the size of all but the largest paintings encountered (3x4m). Even in height alone it is 5 times taller than most paintings. Defects which in smaller paintings might be temporarily corrected by stretching or pressure, propagate in cycloramas to other areas of the painting and remain clearly visible to the naked eye (Fig.7).

Summary:

The study of cyclorama paintings provides an enormous amount of very valuable evidence, the more important because of the amazingly good state of their preservation. An additional advantage is the fact that the stress on every spot of the cyclorama canvas is fairly constant and can be mathematically calculated, as opposed to paintings on rigid stretchers, where constant changes of stress take place. However, changes in temperature and relative humidity are not the only reason for changes in stress. Changes in stress can also be caused by sagging of the canvas, keying out of the stretcher, weight and contractions of the paint, or location of the stress within the stretched

painting. Thus, in a painting held by a stretcher, we have so many variables that it is impossible to isolate a specific cause of decay or to make any concrete statements about the forces responsible for it. In contrast, on cycloramas we know precisely the forces which act on each point of the painting. A cyclorama painting supplies a unique and vast pool of information due to the following factors:

- 1) it provides an enormous area of canvas, approximately 1500-1800m², with a known, homogeneous history,
- 2) every cm² of this canvas can be assumed to have been exposed to a similar set of outside influences,
- 3) in cases where part of the canvas is exposed to sunlight (as in the Mesdag Panorama), a valuable comparison between the sun-lit and the shaded parts can be made,
- 4) records exist which describe the materials and techniques employed to paint cycloramas (cross-sections of the paint layer might be made to verify these records),
- 5) the number of known cycloramas still in existence multiplies this information (at least 20,000m² are easily available for examination),
- 6) most cycloramas are exhibited in places lacking air-conditioning; the effects of such conditions on their surfaces can be studied,
- 7) cycloramas hanging in different weather zones might enable researchers to make comparative studies on the presence or lack of specific effects of outside influences on the state of preservation of these paintings,
- 8) the unique suspension system of cycloramas assures a constant tension on each point of the painting,
- 9) this tension gradually diminishes as we move from the top edge of the painting down to its bottom. Consequently, the effects of stress differences in the canvas on a hundred-year-old paint film can be compared,
- 10) examination of six cycloramas so far has shown striking similarities in the state of their preservation. This is even more important because of the immense quantity of statistically valuable data.

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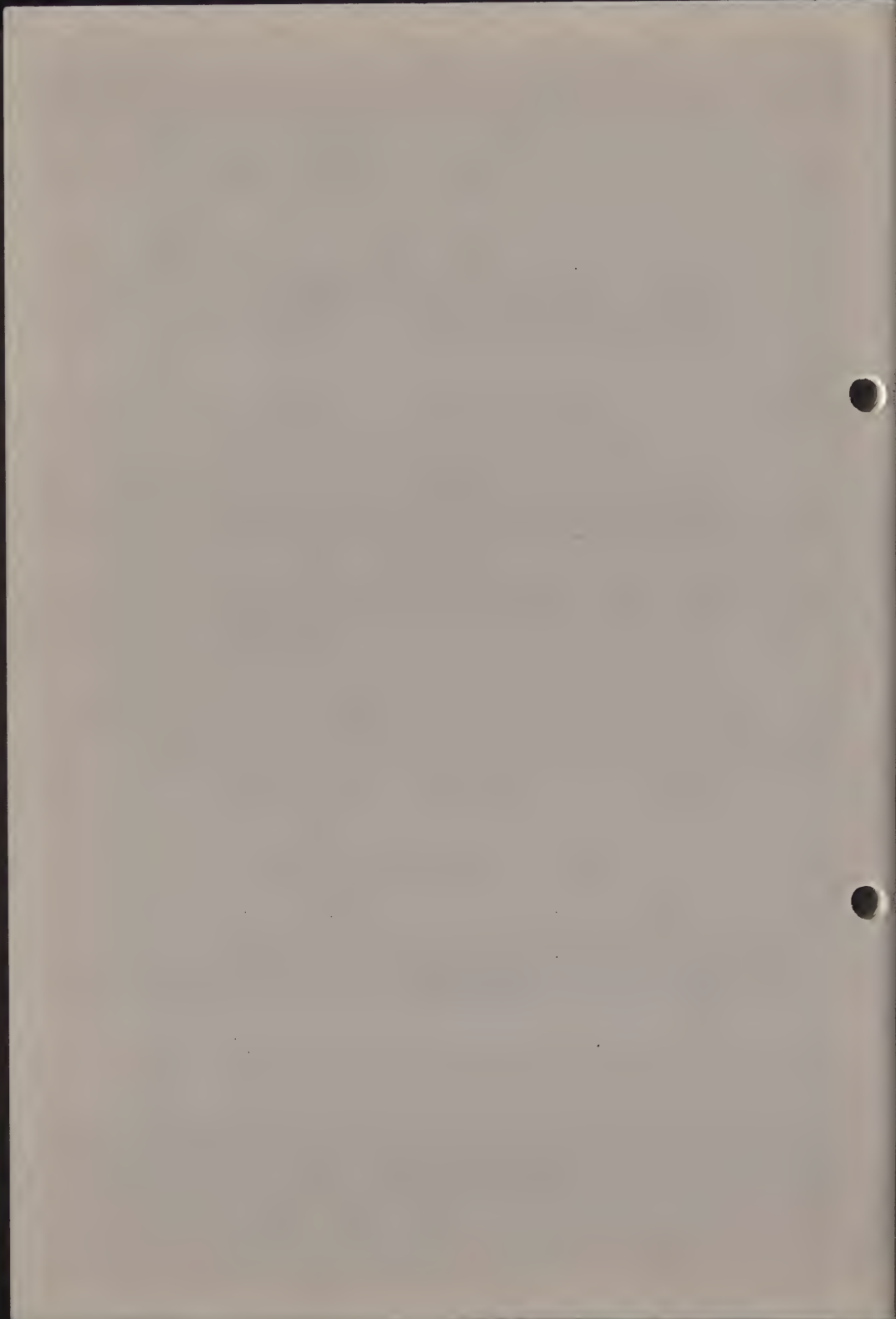
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ETUDE DE L'OPERATION DE DECATISSAGE DES
TOILES DE DOUBLAGE EN LIN. ANALYSE
COMPARATIVE DES CARACTERISTIQUES DES
TOILES DECATIES ARTISANALEMENT ET
INDUSTRIELLEMENT

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RESUME

Le décatissage des toiles de doublage en lin est une opération fondamentale nécessaire à la bonne conduite du rentoilage de tradition française à la colle. Avec pour objectif à terme, la définition d'un certain nombre de recommandations, il apparaissait essentiel de décrire et d'analyser techniquement les gestes des rentoiliers effectuant le décatissage. C'est le but de cet article qui résume les études conduites en collaboration avec deux artisans rentoiliers. Sont également analysées de manière comparative, les caractéristiques des toiles de doublage décaties artisanalement et industriellement.

I - INTRODUCTION

Le rentoilage, notamment de tradition française à la colle, se caractérise par sa méthodologie, qui exige la mise en oeuvre d'une toile neuve de doublage en lin, assez lourde, épaisse et résistante, qui doit subir une préparation préalable appelée décatissage.

Le décatissage de la toile de doublage est

traditionnellement conduit par le rentoileur directement sur le bâti en bois utilisé pour le rentoilage. Les forces et déformations mises en jeu et supportées par la toile de doublage, lors d'une opération de rentoilage complète, ont déjà fait l'objet d'une étude préliminaire dont les résultats ont été présentés à ICOM 1978 à Zagreb (1). L'opération de décatissage est considérée par les rentoileurs traditionnels comme une préparation indispensable qui communique à la toile support des propriétés très spécifiques nécessaires à la bonne conduite du rentoilage à la colle. Les gestes des rentoileurs effectuant une telle préparation méritaient donc d'être analysés de manière assez systématique dans l'objectif d'essayer d'en retenir des règles et d'en expliquer la finalité.

Il est possible depuis quelques années de trouver dans le commerce des toiles décaties selon des procédés industriels. Dans le cadre d'une étude sur le décatissage des toiles de lin, il convenait donc de tenter de définir les caractéristiques respectives des toiles décaties artisanalement et industriellement.

II - ETUDE DU DECATISSAGE ARTISANAL

Le décatissage est une opération pratiquée depuis des siècles sur les étoffes destinées à l'habillement notamment celles en laine et en coton. Ethymologiquement, le terme décatissage signifie : élimination de l'apprêt. Cette opération, conduite en milieu aqueux, permet avec le gonflement des fibres élémentaires, de relaxer une grande partie des contraintes accumulées dans l'étoffe au cours du tissage principalement, et s'accompagne de ce fait d'un retrait du tissu. Le dé-

catissage a donc pour double but, l'élimination de l'ap-
prêt et la stabilisation dimensionnelle des articles
textiles. Il se pratique toujours industriellement sur
des lignes de fabrication souvent sophistiquées qui com-
portent successivement des zones d'humidification du
tissu et des traitements cryogéniques (azote ou ammoniac
liquide).

Le décatissage préparatoire au rentoilage pro-
cède de la même démarche, mais il semble bien que, con-
trairement à ce qui est recherché dans le traitement des
étoffes pour l'habillement où la stabilité dimensionnelle
signifie "retrait limité", dans le cas du rentoilage, une
stabilité dimensionnelle qui ne tolère plus aucun allon-
gement de la toile de doublage, est essentiellement visée.
Cette absence de capacité de fluage de la toile de dou-
blage favorise le rentoilage proprement dit et permet
ultérieurement, au tableau rentoilé de conserver un as-
pect très tendu.

Le décatissage préparatoire, tel qu'il est pra-
tiqué par les rentoilieurs du Service de Restauration de
l'Inspection Générale des Musées Classés et Contrôlés,
peut être subdivisé en 6 étapes :

- 1 - mise en tension de la toile sur un fort bâti
- 2 - mouillage de la toile
- 3 - séchage
- 4 - travail mécanique
- 5 - remise en tension
- 6 - encollage

Les opérations effectuées simultanément par 2 rentoilieurs
dans les locaux de la Manufacture des Gobelins en Février
1980, sont décrites ci-après :

II.1. Les gestes des rentoileurs effectuant le décatissage d'une toile de doublage en lin :

II.1.1. Première mise en tension

- 6 bâtis de plusieurs dimensions ont été garnis de toile : deux de 2,5 m x 2 m., deux de 1,5 m x 1 m. et deux de 1 m x 0,8 m. Pour tendre la toile sur les bâtis, les rentoileurs utilisent une tenaille spéciale à larges mors (8 à 10 cm de largeur) dont les becs sont arrondis pour ne pas couper le tissu, mais qui peuvent comporter une dentelure évitant les glissements. Les manches de cet outil ont une longueur de 25 à 30 cm et sont souvent munis d'un anneau de serrage permettant de maintenir la toile bloquée sans effort de la main. Le clouage s'effectue au marteau à l'aide de pointes de tapissier ; les clous ne sont pas enfoncés complètement dans le bâti de manière à être facilement enlevés à la fin des opérations.

- Les deux opérateurs débutent indépendamment par le grand ou le petit côté du bâti, mais systématiquement commencent par fixer le tissu selon la direction de moindre allongement (en l'occurrence le sens trame de la toile). Le premier côté étant cloué sur toute la longueur (ou largeur) du bâti (1 clou tous les 4-5 cm), le rentoileur procède à la fixation du tissu selon la direction qui s'allonge le plus (ici, sens chaîne). Avant de pointer, l'opérateur tire sur la toile au maximum au niveau d'un des angles du bâti resté libre, en s'aidant de la pince qu'il appuiera sur le bord du bâti, constituant ainsi un levier multipliant par 4 ou 5 l'effort donné par la main. Les rentoileurs fixent ainsi la toile de doublage sur les deux montants du bâti parallèles au

sens chaîne de la toile. Enfin, la toile est fixée sur le 4ème côté du bâti en tendant énergiquement au fur et à mesure du clouage.

- La tension communiquée avec les pinces du rentoileur, est à la limite de la résistance de rupture de la toile (certaines ruptures de fils sont constatées).

II.1.2. Mouillage :

- De l'eau tiède (40°C) est répandue à l'aide d'une éponge à la surface de la toile fixée sur le bâti et mise horizontalement. Le mouillage est suivi d'un brossage énergique à l'aide d'une brosse à poils raides.

- Quantité d'eau utilisée : 2 à 2,5 litres pour un bâti de 2,5 x 2 m.

II.1.3. Séchage :

Effectué à l'air ambiant, le bâti restant horizontal : durée 12 h. environ. Après séchage, la toile apparaît détendue.

II.1.4. Travail Mécanique :

Par des poussées énergiques sur la toile avec la paume de la main, obliquement, des bords vers le centre, l'opérateur contribue à assouplir et détendre encore la toile.

II.1.5. Deuxième tension :

La toile est déclouée du bâti, puis retendue dans les mêmes conditions et positions que la toile initiale. Notons, que le déclouage peut être limité à 3 côtés du bâti : le côté non décloué correspond alors au sens trame du tissu.

II.1.6. Encollage :

La toile est encollée avec une préparation aqueuse de farine de blé, de farine de seigle additionnée d'un peu de phénol comme agent de conservation.

Dans son exécution, le processus est identique au mouillage à la nature du liquide près. Après séchage, la perte de tension de la toile est faible mais sensible.

II.2. Analyse technique des gestes des rentoileurs :

II.2.1. Définition des toiles de doublage :

Les deux toiles employées par chaque rentoileur sont définies ci-après par leurs caractéristiques de construction à l'intérieur du tableau I :

Tableau I

Contexture des toiles de doublage		
	Toile 1	Toile 2
Compte (Nbre fils/cm chaîne)	17,2	17,0
Duitage (" fils/cm trame)	12,9	12,6
Embuvage chaîne (%)	24,8	23,0
" trame (%)	2,2	1,8
Titre chaîne (Tex)	101,1	96,4
" trame (Tex)	109,2	100,4
Masse surfacique (g/m ²)	360	330

On peut observer que les deux toiles sont très semblables et qu'elles présentent un fort embuvage des fils chaîne (embuvage = ondulation des fils dans le tissu) pour un faible embuvage des fils trame. Ces caractéristiques permettent de prévoir a priori que la déformabilité des toiles sera très importante dans le sens chaîne.

A l'intérieur du tableau II ci-après sont regroupées les principales caractéristiques des toiles décaties artisanalement par les deux opérateurs.

Tableau II

Caractéristiques des toiles décaties			
		<u>Toile 1</u>	<u>Toile 2</u>
Masse surfacique (toile décatie non encollée) g/m ²		324	318
Masse surfacique (toile décatie et encollée) g/m ²		506	472
Quantité de colle sèche "		198 (61%)	176 (55%)
Masse surfacique du tissu désencollé		308	296
Embuvage des fils chaîne (%)		10	9
" " " trame (%)		4	1

Du fait des fortes tensions mises en oeuvre lors du décatissage et de la contexture même des toiles de doublage, on constate essentiellement après décatissage, une rectification des fils de chaîne. Les fils de trame initialement peu ondulés dans la toile ne sont pas ou peu affectés par l'opération de décatissage.

II.2.2. Allongement de la toile au cours du décatissage :

Ces mesures ont été réalisées grâce à un carroyage effectué sur les toiles initiales (carrés de 10 cm ce côté).

Il serait trop long ici de reproduire le détail de ces mesures, mais on peut résumer les observations principales suivantes :

- Pour des toiles assez semblables, les tensions mises en jeu par les rentoileurs sont très différentes et les déformations résultantes également :
- . le premier opérateur a communiqué à sa toile une déformation globale de 12 % chaîne et 0,3 % trame.
- . le second opérateur a communiqué à sa toile une déformation de 8 % chaîne et 0,6 % trame.

Il est logique de constater que l'opérateur qui allonge le moins la chaîne, allonge plus le sens trame.

- La répartition des déformations le long du bâti est très hétérogène :

- . Les déformations vont croissant du bord où le tissu est cloué initialement à celui où l'opérateur exerce l'effort de traction à l'aide de sa pince (quel que soit l'opérateur, et indépendamment de la contexture de la toile).
- . Le long d'un même bord du bâti, la partie médiane, est celle qui a subi la plus faible déformation (l'amplitude des écarts étant fonction de l'opérateur).
- . Les déformations observées lors de la seconde mise en tension (après mouillage et séchage) sont beaucoup plus importantes que celles effectuées lors de la première mise en tension.

III - REACTION DES TOILES INITIALES, DECATIES ET ENCOLLEES AUX CONDITIONS CLIMATIQUES VARIABLES

III.1. Description du mode opératoire :

Des éprouvettes de toile de 50 x 50 cm sont montées sur des dispositifs spéciaux permettant de les maintenir à chaque extrémité. La mâchoire inférieure du dispositif est reliée à un capteur de force, la mâchoire supérieure est reliée à un dispositif mécanique permettant de communiquer à l'éprouvette une déformation correspondant à une tension initiale désirée. Le dispositif permet de tester des éprouvettes suffisamment larges (50 cm) pour que l'on puisse admettre qu'un état de contrainte bi-dimensionnelle soit établi dans la plus grande partie de l'échantillon testé.

Les dispositifs (le premier pour une éprouvette testée sens chaîne, le second pour une éprouvette testée sens trame) sont introduits à l'intérieur d'une enceinte climatique programmée pour effectuer les cycles suivants:

- dans l'ordre : 20°C/65 % H.R. - 10°C/35 % H.R. - 40°C/90 % H.R.

Le cycle d'essai est répété deux fois en maintenant chaque condition 8 h.

La tension initiale communiquée aux éprouvettes est de 10 daN - m/l.

Des enregistreurs permettent de suivre en continu l'évolution de la tension des éprouvettes en cours d'essai.

III.2. Résultats :

Les variations de la force qui s'exerce sur les éprouvettes en fonction des cycles H.R. % - °C, sont représentées par les courbes de la figure 1 pour la toile n° 1 et par les courbes de la figure 2 pour la toile n°2. Sur chaque graphique, le comportement des toiles décaties artisanalement est étudié comparativement à celui des toiles initiales non décaties. A l'analyse de ces courbes on peut constater immédiatement, l'énorme différence de comportement entre toiles décaties et non décaties :

- Après une relaxation initiale - faible d'ailleurs pour les toiles décaties - une tension importante se développe lors de la première transition H.R. % - °C, dans les toiles décaties. Les toiles non décaties présentent un comportement inverse à celui des toiles traitées, en début d'essai. Après avoir subi un certain nombre de conditions climatiques différentes, les toiles décaties et non décaties montrent des réactions en phase.

- Les toiles non décaties se détendent complètement et systématiquement aux conditions 10°C - 35 % H.R. et 20°C - 65 % H.R.. Les toiles décaties restent toujours très tendues, à l'exception de la toile n° 1 qui se détend sans trame aux conditions très humides.
- Il est assez remarquable de constater la bonne reproductibilité des réactions des toiles décaties d'un cycle sur l'autre : attribuable certainement à la rigueur des traitements de décatissage.
- Le rentoileur n° 2, qui a limité les déformations de sa toile (sens chaîne) lors du décatissage et qui a déposé moins de colle en fin d'opération, a obtenu une toile décatie qui montre un comportement équilibré sens chaîne/sens trame lors des essais en condition climatique variable. Au contraire, l'opérateur n° 1 qui a beaucoup plus déformé sa toile lors des mises en tension successives et qui a déposé plus de colle, a obtenu une toile à comportement plus dissymétrique.

IV - ETUDE DU COMPORTEMENT D'UNE TOILE DECATIE DANS L'INDUSTRIE

Les réactions d'une toile décatie dans des conditions industrielles, sous l'effet de variations climatiques analogues à celles retenues pour les toiles décaties artisanalement, sont représentées par les courbes de la figure 3. Le comportement de cette toile apparaît donc conforme à celui des toiles initiales non décaties des figures 1 et 2 : réactions de faibles amplitudes, avec détension complète aux conditions sèches et légère recouvrance aux conditions humides. De toute évidence cette toile préparée industriellement a subi l'élimination de l'apprêt, mais nullement le travail mécanique qui caractérise le décatissage artisanal.

V - CONCLUSIONS

Le décatissage constitue bien une opération importante qui communique à la toile de doublage en lin des caractéristiques spécifiques, notamment : absence de fluage, même aux conditions très humides et recouvrance très importante, aux conditions sèches. Les gestes des artisans qui exécutent cette opération apparaissent assez semblables et conduisent à des résultats voisins. Comparativement, les toiles décaties industriellement sont loin de posséder les caractéristiques de celles travaillées artisanalement et se différencient très peu, dans leur comportement à l'état tendu, des toiles non décaties.

Un écart de comportement sensible peut apparaître entre sens chaîne et sens trame des toiles décaties de manière artisanale. Dans ces conditions, le fait de croiser les chaînes de la toile de doublage et du tableau à rentoiler pourrait présenter certains inconvénients. Ce point fait l'objet d'une étude entre le service de Restauration des Musées Classés et Contrôlés et l'ITF.

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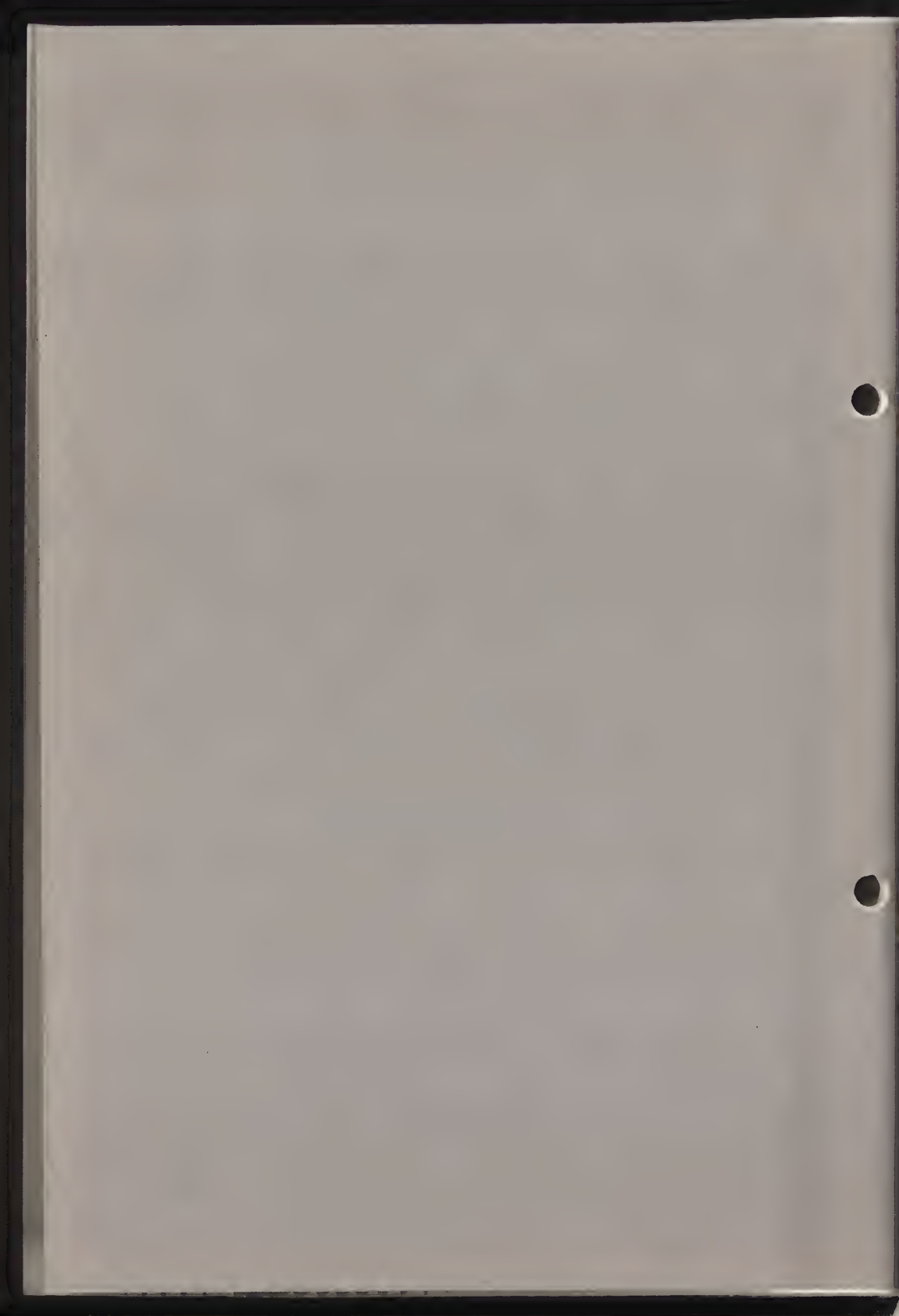
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ETUDE DES PROPRIETES DE DOUBLAGES
EXPERIMENTAUX A LA COLLE SYNTHETIQUE

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RESUME

Différents doublages expérimentaux ont été étudiés en faisant varier les paramètres suivants :
contexture de la toile de doublage en lin - décatissage préalable ou non de la toile de doublage - mode d'encollage de la toile de doublage - viscosité de la résine synthétique et mode d'application - conservation ou non des bandes de tension du tableau fictif.

Sur ces rentoilages ont été analysés comparativement : le comportement à l'état tendu sous l'effet de variations climatiques simulées - les cinétiques de sorption-désorption de l'humidité - certaines propriétés mécaniques (résistance au décollement - élasticité).

I - INTRODUCTION :

Avec le développement des matériaux de synthèse, les méthodes traditionnelles de rentoilage à la colle ou à la cire font de plus en plus l'objet d'études comparatives avec des méthodes plus modernes mettant en oeuvre soit des toiles de doublage en fibres chimiques (à la place de la toile traditionnelle en lin), soit des résines de synthèse (1, 2, 3).

Dans le présent travail sur les doublages à la colle synthétique, nous avons tout particulièrement essayé de dégager l'influence sur les caractéristiques finales du rentoilage des paramètres suivants :

- Contexture de la toile de doublage en lin, le procédé de décatissage et ou encollage.
- Viscosité de la résine (haute H, moyenne M, basse B densités) et dilution de la résine.

- Modes d'application de la résine et repassages.
- Conservation ou non des bandes de tension du tableau (tableau fictif spécialement préparé pour ces essais).

Dans l'esprit des études antérieures conduites sur les rentoilages traditionnels (réf. 3), nous avons analysé les méthodes à la résine synthétique afin de définir : leur comportement à l'état tendu sous l'effet de variation d'ambiance simulée - les phénomènes d'échange de l'humidité entre l'ambiance et le rentoilage - certaines caractéristiques mécaniques permettant d'apprécier a priori la qualité de l'opération et sa réversibilité (propriétés élastiques, résistance au décollement).

II - CARACTERISTIQUES DES PRODUITS UTILISES POUR LES DOUBLAGES

II.1. Tableau fictif :

Pour des raisons de simplicité et afin de permettre l'analyse comparative des résultats, il a été décidé de réaliser ces rentoilages à l'aide d'un tableau fictif, bien qu'il eut été plus réaliste de mettre en oeuvre un tableau ancien "affaibli".

Tous les doublages ont été réalisés avec ce même tableau fictif préparé à partir d'une toile à peindre dont les caractéristiques sont les suivantes :

- masse au m² : 154 g.
- épaisseur : 0,46 mm
- compte : 11,5 fils/cm
- duitage : 13,6 fils/cm
- titre chaîne : 53,4 tex
- titre trame : 61,1 tex
- embuvage fils chaîne : 10,1 %
- embuvage fils trame : 1,3 %

La préparation du tableau fictif a nécessité un montage sur châssis de la toile à peindre, sans décatissage préalable, puis un encollage à la colle de peau (colle Tottin 10 g. pour 100 g. d'eau) et une préparation blanche à chaud (colle Tottin idem ci-dessus + blanc d'Espagne 40 g.), enfin, deux couches de vernis Tallens.

Caractéristiques du tableau fictif ainsi préparé :

- masse surfacique : 377 g/m²
- épaisseur : 0,50 mm

II.2. Toiles de doublage :

Trois toiles en lin différentes ont été mises en oeuvre pour la préparation de ces rentoilages.

Les caractéristiques de ces 3 toiles apparaissent à l'intérieur du Tableau 1 ci-après :

Tableau 1

Caractéristiques	Toile Dreyfus	Toile Biebuyck	Toile J.B.W. encollée
Masse au m ² (g)	299	343	229
Compte (fils/cm)	11,7	17,4	22,2
Duitage -"-	11,4	12,4	15,5
Embuvage chaîne (%)	11,0	21,5	12,5
Embuvage trame (%)	3,0	2,3	2,0
Titre chaîne (tex)	127	100	-
Titre trame (tex)	115	98	-
Epaisseur (mm)	0,62	0,95	0,52

Deux rentoilages ont été réalisés à partir des toiles Dreyfus et Biebuyck, préalablement décaties. L'opération de décatissage ayant pour double but : l'élimination de l'apprêt et la stabilisation dimensionnelle de la toile (absence de fluage) (réf. 4).

Six autres rentoilages ont été réalisés à partir de la toile J.B.W. encollée non décatie.

III - CARACTERISATION DES RENTOILAGES

Rentoilage n° 1 (R₁) :

Toile de doublage Dreyfus décatie et encollée une fois au Rhodoviol à 10 % dans l'eau. Pulvérisation de la résine synthétique Rhodopas (colle vinylique) M à 30 % (3 parts de résine pour 2 parts de Méthanol) sur les deux toiles : tableau fictif et doublage.

Repassage immédiat à 110°C suivi d'un deuxième repassage après 18 h.

Rentoilage n° 2 (R₂) :

Toile de doublage Biebuyck décatie et encollée deux fois au Rhodoviol (à 3 % et 10 % dans l'eau). Pulvérisation de la résine Rhodopas M à 30 % sur les deux toiles.

Repassage après 18 h.

Rentoilage n° 3 (R₃) :

Toile de doublage J.B.W. (Marin) réf. R.C.M.,
encollée commercialement à la colle de peau. Pulvérisa-
tion de la résine Rhodopas M sur les deux toiles. Re-
passage immédiat suivi d'un deuxième repassage après 20 h.
et d'un troisième repassage final.

Rentoilage n° 4 (R₄) :

Toile de doublage J.B.W.
Pulvérisation sur les deux toiles d'un mélange
de résines Rhodopas H (2 parts) et Rhodopas M (1 part).
Les deux résines sont préalablement diluées à l'alcool.
Repassage après séchage complet.

Rentoilage n° 5 (R₅) :

Toile de doublage J.B.W.
Pulvérisation de la résine Rhodopas H sur la
toile de doublage. Pulvérisation sur le revers du tableau
fictif de la résine Rhodopas B (2 parts de résine pour
1 part de Méthanol).
Repassage après évaporation partielle.

Rentoilage n° 6 (R₆) :

Toile de doublage J.B.W.
Pulvérisation sur le revers du tableau fictif
de la résine Rhodopas H. Pulvérisation sur la toile de
doublage de la résine Rhodopas B. Dilutions: résine H
1 part pour 10 p. alcool; résine B 2 p. pour 1 p. alcool
Repassage après séchage partiel.

Rentoilage n° 7 (R₇) :

Toile de doublage J.B.W.
Pulvérisation de la résine Rhodopas B sur les
deux toiles. Dilution : 3 parts résine pour 2 p. alcool.
Repassage après séchage partiel.

Rentoilage n° 8 (R₈) :

Idem R₇, mais suppression des bandes de tension
du tableau fictif.

Les principales caractéristiques de ces rentoi-
lages sont consignées à l'intérieur du Tableau 2 ci-après.
On peut déjà remarquer que les taux de colle déposés dans
les rentoilages avec toile de doublage J.B.W. (R₃ à R₈)
sont les plus importants, chaque fois que la viscosité de
la résine pulvérisée est faible : colle B utilisée
pour les rentoilages R₅, R₆, R₇.

Tableau 2

Rentoilages	Masse Surfacique (g/m ²)	Epaisseur (mm)	Taux de colle (%)
R ₁	895	1,67	24,5
R ₂	894	1,75	19,5
R ₃	738	1,04	17,9
R ₄	751	0,97	19,3
R ₅	754	1,06	20
R ₆	755	1,08	19,7
R ₇	762	0,97	20,4
R ₈	741	0,97	18,2

Notons également que le rentoilage R₁ préparé sur une toile de doublage constituée de fils assez gros et à partir d'une colle de viscosité moyenne a exigé le taux de colle le plus élevé.

IV - ETUDE COMPARATIVE DES PROPRIETES DES RENTOILAGES :

IV.1. Stabilité dimensionnelle des rentoilages :

Les méthodes utilisées ont été décrites à ICOM Zagreb 1978 (Réf. 3). Rappelons brièvement que le comportement à l'état tendu des rentoilages est étudié sur des éprouvettes, montées sur des supports spéciaux équipés de capteurs de force qui permettent d'enregistrer en continu, la tension qui s'exerce sur les éprouvettes. Les porte-échantillons sont disposés à l'intérieur d'une enceinte climatique programmée pour effectuer les conditions suivantes :

- 20°C - 65 % Humidité Relative (condition de
- 10°C - 35 % H.R. référence)
- 10°C - 90 % H.R.
- 40°C - 35 % H.R.
- 40°C - 90 % H.R.
- 20°C - 65 % H.R.

chaque condition est maintenu 16 h. chaque transition étalée sur une durée de 2 h.

La tension initiale appliquée aux éprouvettes est de 10 daN mètre linéaire, équivalente à la tension moyenne qui s'exerce sur les tableaux montés sur châssis définitif.

Avant d'analyser les résultats obtenus sur les rentoilages, il est intéressant d'examiner ceux caractéristiques des divers constituants élémentaires, à savoir : tableau fictif, toiles décaties (Dreyfus, Biebuyck), toile encollée non décatie (J.B.W.).

- sur la fig. 1 ont été regroupées les courbes caractéristiques du comportement à l'état tendu du tableau fictif et de la toile J.B.W. encollée. On peut donc constater que sur ces supports qui possèdent une couche de préparation de caractère hydrophile, les transitions conditions climatiques humides - conditions sèches, entraînent l'apparition de forces de retrait, donc une mise en tension supplémentaire de l'éprouvette. Au contraire, les transitions conditions sèches, conditions humides entraînent un relâchement total de la tension.
- sur la fig. 2 ont été regroupées les courbes caractéristiques du comportement à l'état tendu d'une toile décatie (toile initiale Biebuyck). On constate que sur ces toiles travaillées mécaniquement par le décatissage, et qui ne sont pas encollées, il se produit une montée en tension systématique lors des transitions conditions sèches - conditions humides. Ces recouvrances correspondent aux mécanismes de libération des forces de retrait dans une toile qui a été très déformée par allongement lors du décatissage. Le décatissage affectant plus le sens chaîne que le sens trame des toiles (réf.4) il est normal de constater des recouvrances plus importantes sens chaîne que sens trame. Les courbes de la fig. 3 correspondant d'une part à la toile non décatie et d'autre part à la toile décatie, montrent que le décatissage a pour effet, au niveau de ces tests, d'amplifier considérablement la réponse naturelle des toiles de lin aux variations d'ambiance.

Compte-tenu de ces résultats, on peut s'attendre à ce qu'une toile décatie et encollée avec une préparation hygroscopique présente un comportement mixte, à savoir : recouvrance à chaque transition conditions humides - conditions sèches, surtout due aux interactions colle hygroscopique et textile; recouvrance aux conditions humides spécifiques des toiles de lin décaties.

Ce comportement caractéristique des toiles décaties et encollées a bien été vérifié expérimentalement (cf. réf. 4).

Cas des Rentoilages :

Les 3 premiers rentoilages R_1 , R_2 , R_3 se différencient essentiellement par le type de la toile de doublage. Les 2 premiers sont préparés sur des toiles de lin décaties, le troisième sur une toile de lin non décatie et encollée. Les courbes de la fig. 4 illustrent le comportement à l'état tendu de ces 3 rentoilages dans des

ambiances variables. Compte-tenu des remarques précédentes on peut constater que les rentoilages R_1 et R_2 (composites élaborés à partir de toiles décatiées, d'un tableau fictif et de colle) sont toujours dans des états de tension supérieure à la tension initiale, quelles que soient les conditions d'ambiance. Par contre, le rentoilage n° 2 qui n'est pas préparé à partir d'une toile décatie ne montre pas le phénomène de recouvrance aux conditions humides et, de ce fait, les courbes indiquent une chute de la tension de ce rentoilage à chaque condition humide ($10^\circ\text{C} - 90\% \text{ H.R.}$ et $40^\circ\text{C} - 90\% \text{ H.R.}$). Le rentoilage n° 3 est également celui pour lequel le comportement sens chaîne et sens trame est le moins dissymétrique.

Pour les autres rentoilages de R_4 à R_8 , le comportement observé est voisin de celui du rentoilage 3, seules changent pour ces rentoilages les conditions d'application de la colle synthétique et il ne semble pas que ces paramètres influent de manière très significative sur le comportement des rentoilage à l'état tendu. A titre d'exemple, apparaît sur la fig. 5 le cas du rentoilage n°4: on constate toujours et systématiquement, les recouvrances aux conditions sèches, les chutes de tension aux conditions humides et le comportement symétrique chaîne/trame.

IV.2. Taux d'humidité et vitesse de désorption :

Pour la mesure des taux d'humidité des rentoilages à différentes conditions d'ambiance, des échantillons de 10 cm x 10 cm ont été prélevés dans les rentoilages et placés à l'intérieur de l'enceinte climatique. Au terme de chaque cycle, les taux d'humidité fixés par les éprouvettes ont été calculés par rapport à leur masse déshydratée ; les résultats sont consignés à l'intérieur du Tableau 3 ci-après :

Tableau 3

	20°C 65% HR	10°C 35% HR	40°C 35% HR	40°C 90% HR
	taux de reprise d'humidité en %			
R_1	6.7	5.3	4.6	14.1
R_2	6.9	5.6	4.6	15.0
R_3	6.9	5.8	4.7	13.7
R_4	6.7	5.4	4.6	15.2
R_5	6.9	5.6	4.9	16.2
R_6	7.1	5.6	4.9	16.4
R_7	7.0	5.6	4.9	14.8
R_8	7.2	5.6	4.9	15.4

On ne constate pas de différences très importantes entre les rentoilages en ce qui concerne les taux de reprise d'humidité aux différentes conditions. Néanmoins, les

changements de conditions climatiques entraînent des modifications de taux de reprise qui peuvent être très importantes, qui permettent de comprendre les réactions à l'état tendu des rentoilages telles qu'elles ont été décrites dans les paragraphes précédents.

Les phénomènes de désorption de l'humidité ont été suivis sur des éprouvettes mises en équilibre dans une enceinte climatique à 10°C 90 % HR, sorties et pesées tous les 1/4 d'heure dans une salle conditionnée à 20°C 65 % HR. Les courbes de désorption de l'humidité obtenues permettent de constater :

- que le rentoilage n° 1 désorbe très rapidement.
- que le rentoilage n° 2 désorbe régulièrement et plus longtemps que R₁.
- que les différences entre les autres rentoilages sont faibles.

Pour mettre en évidence le rôle de la colle synthétique et éventuellement celui de la colle déposée sur la toile de doublage (Rhodoviol), les courbes de désorption ont été tracées pour les différents constituants des rentoilages. A titre d'exemple, les courbes obtenues sur le rentoilage n° 2 apparaissent sur la fig. 6. Il est évident à l'examen de ces courbes que les composants, tableau fictif et toile de doublage, ne se comportent pas dans le rentoilage comme il le font isolément :

- pendant les 2 - 3 premières heures, le rentoilage désorbe plus lentement que les deux éléments associés. Mais ensuite, le rentoilage continu à désorber alors que les éléments isolés sont stabilisés. Ces résultats signifieraient que les colles ralentissent les échanges à l'intérieur du rentoilage et absorbent une quantité importante d'humidité (cf. tableau 3)
- dans le cas de ce rentoilage n° 2, il faut prendre en compte, à la fois, la couche de colle Rhodoviol déposée sur la toile de doublage, la résine synthétique et la préparation de la toile à peindre.

IV.3. Résistance au décollement :

Les essais ont été effectués sur des éprouvettes de 200 x 50 mm. C'est la toile de doublage qui a été soumise à la tension et décollée du tableau fictif. Les essais ont été conduits de la manière suivante :

- l'éprouvette a été fixée sur un support rigide (plaque d'aluminium) à l'aide d'un ruban adhésif.
- la toile de doublage a été décollée manuellement sur toute la largeur et sur la moitié de la longueur de l'éprouvette. La partie décollée a été fixée dans la mâchoire supérieure du dynamomètre.

- le tableau fictif, collé à la plaque d'aluminium, a été fixé dans la mâchoire inférieure du dynamomètre.

La vitesse de traction a été fixée à 100 mm/mn.

Le test de décollement a été effectué sur des éprouvettes prélevées dans les rentoilages "neufs" et dans les rentoilages ayant subi un vieillissement accéléré en enceinte climatique dans des conditions de température et d'humidité relative décrite en IV.1. Les résultats de ces essais apparaissent à l'intérieur du Tableau 4 ci-après :

Tableau 4

	Sens Chaîne		Sens Trame		Moyenne	
	Neuf	Vieilli	Neuf	Vieilli	Neuf	Vieilli
R ₁	5.3	6.10	5.4	5.70	5.35	5.90
R ₂	2.4	2.80	3.4	5.80	2.90	4.30
R ₃	1.4	1.7	1.9	1.80	1.65	1.75
R ₄	1.7	1.9	2.2	2.00	1.95	1.95
R ₅	1.1	1.01	1.1	1.20	1.10	1.10
R ₆	1.7	0.97	2.6	1.12	2.15	1.04
R ₇	1.6	1.19	1.7	1.62	1.65	1.40
R ₈	1.8	0.88	1.7	1.16	1.75	1.02

Toutes les résistances sont exprimées en daN.

Ces résultats permettent de faire les observations suivantes :

- les rentoilages 1 et 2 préparés sur toiles décaties ont exigé plus de colle et, de ce fait, présentent une résistance au décollement plus élevée. Comparativement, les rentoilages 3 à 8 présentent une résistance au décollement plus faible qui pourrait s'expliquer par la formation d'un film de colle plus homogène sur la surface des toiles.
- la mise en oeuvre de la résine B (basse densité) seule, conduit à la formation d'un film beaucoup moins homogène qui se détache beaucoup moins facilement du tableau fictif que dans les cas où cette résine est utilisée en mélange avec d'autres résines.
- du point de vue de la réversibilité immédiate les rentoilages 3 et 5 sembleraient donner les meilleurs résultats ; le rentoilage n° 5 du fait des faibles forces de décollement, le rentoilage n° 3 du fait que la résine est compacte et forme un film bien homogène.

- après vieillissement, les forces de décollement sont plus importantes dans les rentoilages 1, 2, 3 et beaucoup plus faibles pour les rentoilages 6, 7, 8. Il semblerait que la résine Rhodopas B assurerait dans le temps, un moins bon collage que les autres résines.
- en comparant les forces de décollement des rentoilages 7 et 8, avant et après vieillissement, il semblerait que la suppression des bandes de tension conduise à un affaiblissement de l'adhésion : en l'absence de ces bandes (R8), la colle serait plus sollicitée lors des changements d'ambiance (contrainte de cisaillement entre les deux toiles) et s'affaiblirait progressivement.

IV.4. Elasticité :

Le comportement élastique des rentoilages a été étudié en mettant en oeuvre un test qui simule les déformations que peut subir accidentellement un tableau lors d'un transport, d'une exposition, etc.. Il s'agit d'un test de "pochage" qui s'effectue sur des éprouvettes circulaires de 140 mm de diamètre, fixées dans un cadre métallique rattaché à la pince mobile du dynamomètre; une calotte sphérique fixée sur l'autre prince du dynamomètre permet d'exercer une compression sur la surface libre de l'éprouvette : vitesse de compression retenue 10 mm/mn. - force maximale de compression - 10 daN.

Les éprouvettes ont été soumises à un premier cycle de compression/décompression, puis après relaxation de 15 mn, à un second cycle de déformation.

Les courbes de déformation enregistrées ont permis de calculer des paramètres de récupération élastique immédiate et retardée, exprimées en % qui figurent à l'intérieur du Tableau 5 :

Tableau 5

Tableau fictif	Récupération élastique immédiate %	Récupération élastique retardée %
	52.2	75.0
R1	71.4	99.2
R2	67.1	91.2
R3	56.4	80.4
R4	44.4	63.3
R5	53.4	83.5
R6	60.7	83.6
R7	54.4	83.0
R8	61.4	84.2

A l'analyse de ces résultats on peut constater que le doublage en général augmente l'élasticité du tableau fictif ; le rentoilage n° 4 constitue une exception, mais il faut remarquer que dans ce cas, le repassage final a été conduit après séchage complet de la résine et en utilisant une chaleur forte. Les rentoilages 1 et 2 sur toiles de doublage décaties sont ceux qui possèdent les caractéristiques élastiques les meilleures. En outre, il semblerait que l'utilisation d'une résine de moyenne densité (Rhodopas M) sur une toile de doublage non décatie ne conduise pas aux meilleurs résultats en ce qui concerne l'élasticité.

V - CONCLUSIONS

Cette étude comparative sur différents doublages à la résine synthétique a permis de rassembler un nombre important de résultats qui, d'ores et déjà, conduisent aux conclusions suivantes :

- la mise en oeuvre d'une toile de doublage en lin décatie permet d'assurer, dans les conditions climatiques humides, le maintien du tableau doublé et d'éviter ainsi toutes relaxations de tension rédhibitoires qui ne manquent pas de se produire dans de telles conditions, avec des doublages réalisés sur toiles non décaties.
- la mise en oeuvre d'une toile de doublage décatie semble conduire à l'utilisation d'une quantité de résine synthétique plus importante que dans le cas où le doublage est fait avec une toile non décatie. Ce taux de colle plus important explique aussi les forces de décollement plus élevées qui rendront la réversibilité plus délicate.
- des résines synthétiques de faible viscosité, déposées par pulvérisation, conduisent à des films de colle qui s'affaiblissent par vieillissement. Au contraire, la cohésion obtenue avec une colle de densité plus grande s'améliore avec le vieillissement.
- la suppression des bandes de tension du tableau conduit semble-t-il à un affaiblissement prématuré du film de résine utilisé au doublage.
- un repassage trop sévère, après séchage de la colle, peut entraîner une perte des caractéristiques élastiques du doublage.

Un certain nombre d'observations serait à confirmer en utilisant cette fois pour le doublage, un tableau réel plutôt qu'un tableau fictif.

La question relative au croisement des sens

chaîne de la toile de doublage et du tableau se pose également, notamment pour une toile de doublage décatie.

Ces deux derniers points font l'objet de travaux complémentaires dans le cadre d'une convention de recherches entre les Musées Classés et Contrôlés et l'ITF.

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Fig. 1

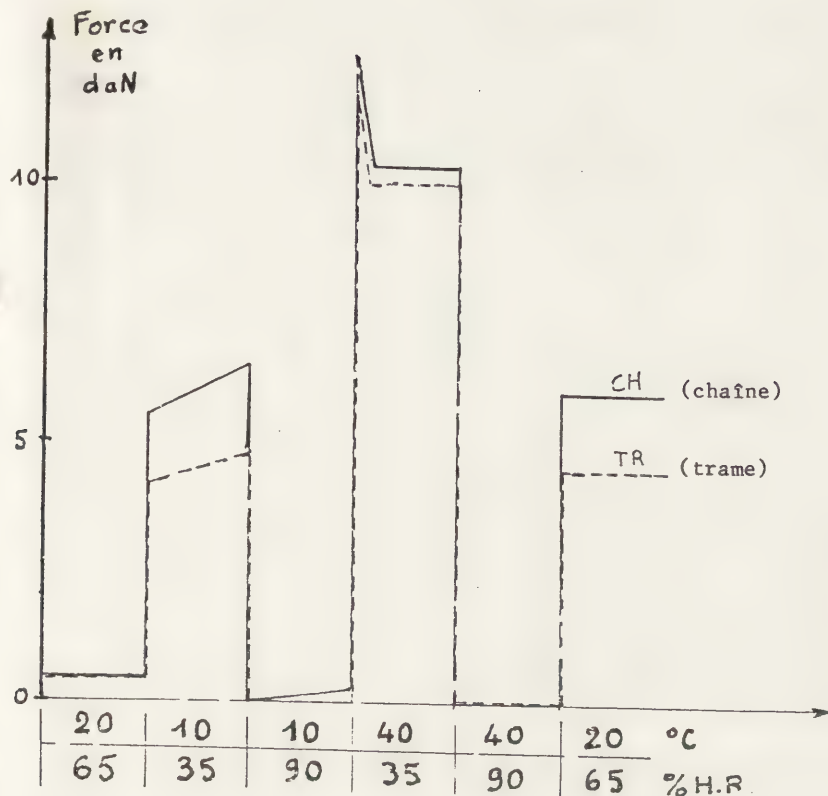
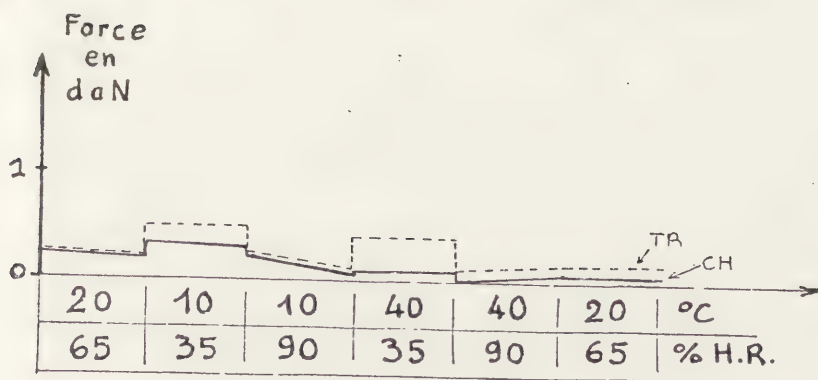


Tableau fictif



Toile J.B.W. (encollée colle de peau)

Fig. 2

Toile de lin décatie

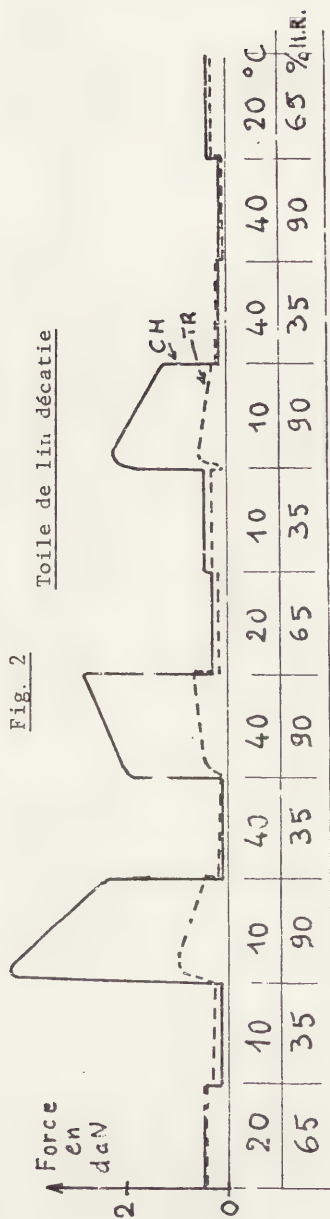


Fig. 3

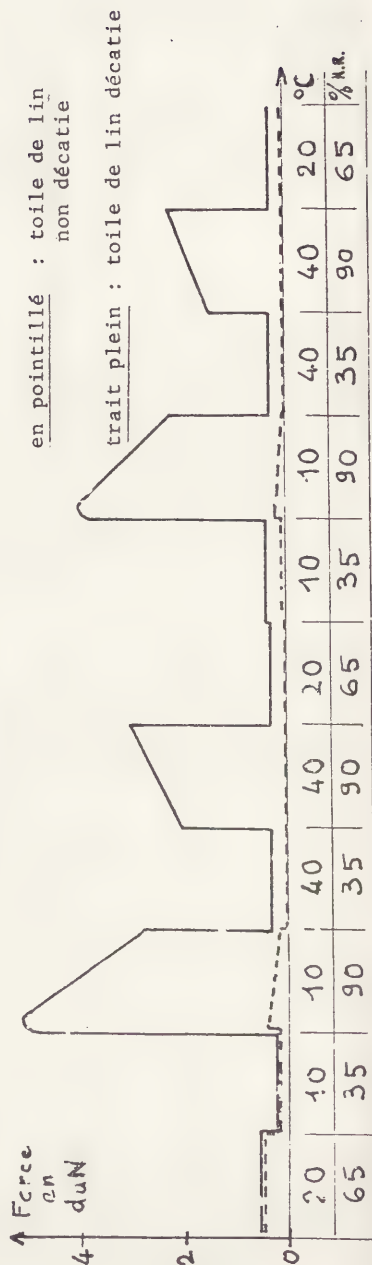


Fig. 4

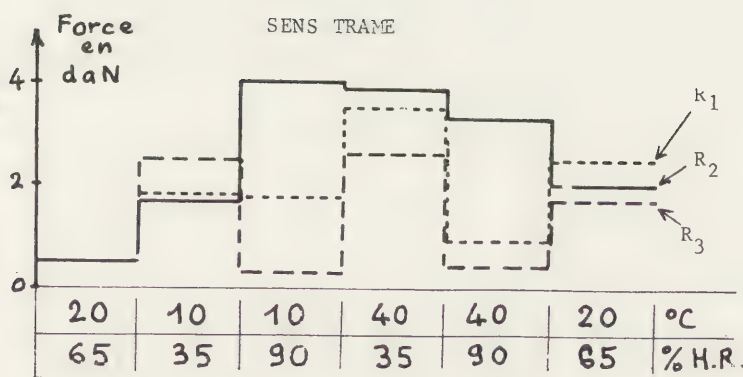
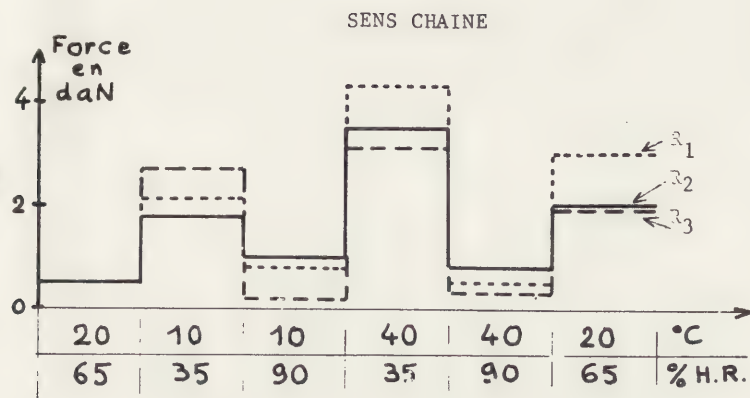


Fig. 5

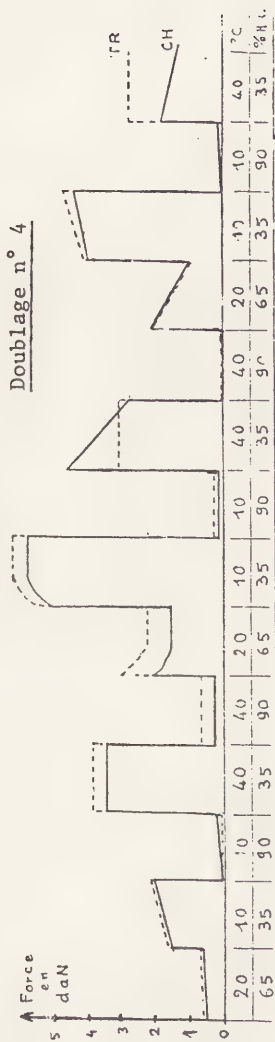
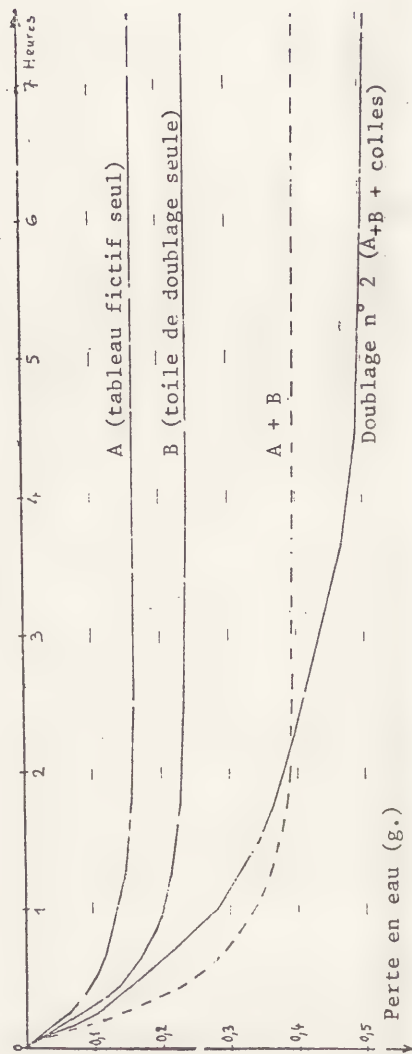


Fig. 6



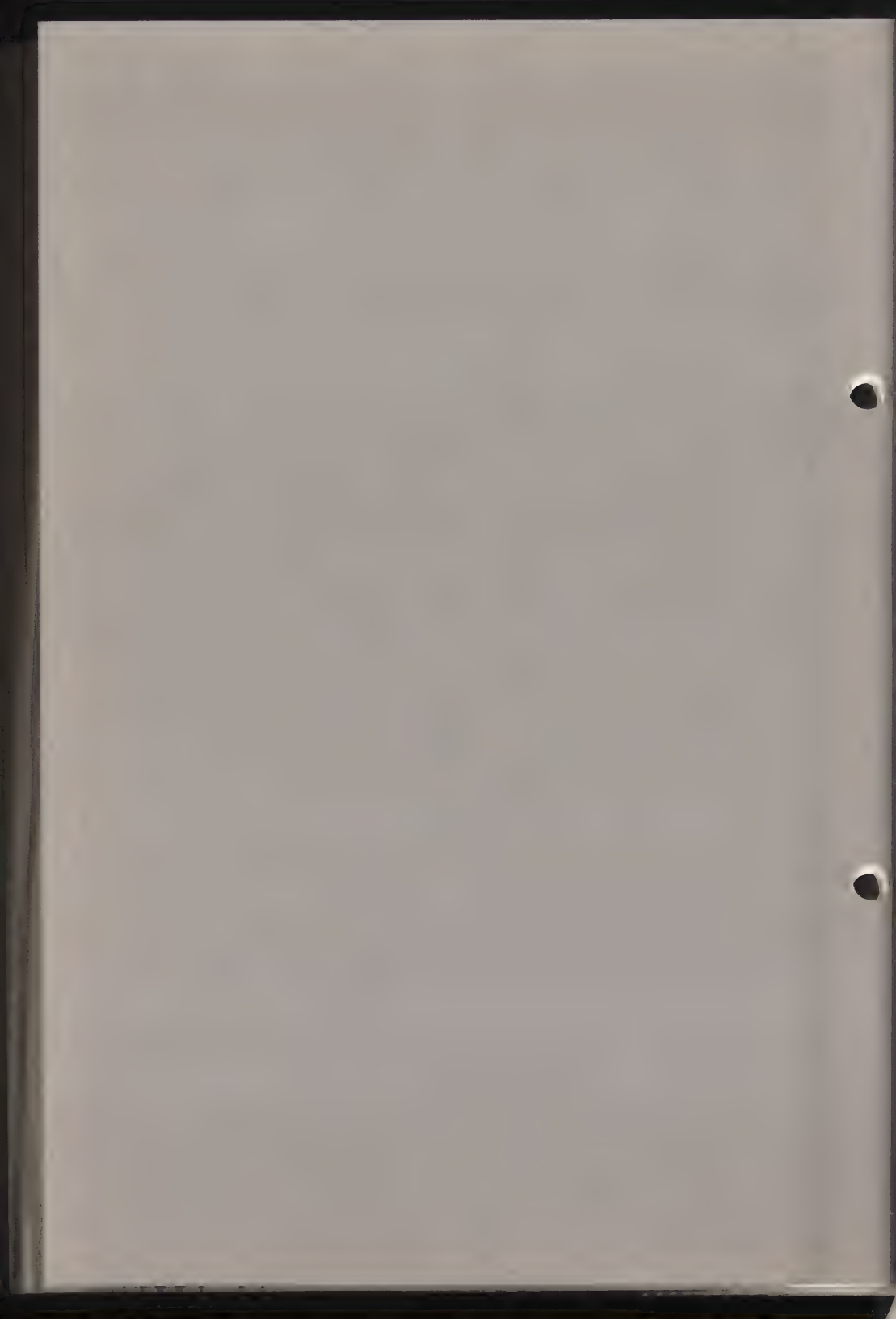
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SOME PROBLEMS AFFECTING CHOICE, FORMULATION
AND APPLICATION OF MATERIALS IN RESTORATION
AND LINING

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Working Group: Structural Restoration of
Canvas Paintings



SOME PROBLEMS AFFECTING CHOICE, FORMULATION AND APPLICATION
OF MATERIALS IN RESTORATION AND LINING

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Abstract

Today the restorer has access to a multitude of materials for restoration, consolidation and lining all of which have been proved beyond doubt to be useful.

Despite this, conversations with colleagues have shown us that there is a growing uncertainty with regard to the choice of the right material, its preparation, in some cases its correct dilution, and above all its correct application.

The point then of our paper is not to critically examine specific materials, but to indicate the problems of application, the gaps between chemical/physical basic information on the one hand and practical experience on the other - that is: that the former can give little information on the actual concrete problem of application, as it does no more than give a very scientific explanation of basics, which is often too much for the practising restorer and results in confusing him.

Furthermore we shall restrict ourselves in this paper to the examples of resins and solvents, although the problems with regard to choice and correct application are very much the same as for other materials, and apply especially to apparatus.

Although the restorer still works today with well known traditional resins, he uses more and more often modern synthetic polymer resins, because he recognises their advantages. Unfortunately however he usually possesses only a limited amount of information about their correct application. It is indeed true that such information on modern resins was made available decades ago - we need only mention the excellent works of Robert Feller Nathan Stolow and Elizabeth Jones, which are still valid. These basic works made the restorer familiar with those modern resins which rightfully are still used. In this way the experimental and theoretical side of these resins has been greatly clarified. Their excellent qualities in restoration (i.e. reversibility and resistance to ageing) are recognised around the world without exception. The standard works we have cited contain all the most important information for a scientifically trained restorer - i.e. tables of solubility, hardness, viscosity etc. as well as formulae for specific use and application.

For the restorer at the easel however this is often just double dutch; for the results and information contained in these standard works relate completely to raw materials, or so called semi-products, which are never considered nor distributed by the manufacturer (the chemical industry) as finished products. They were scarcely ever considered as being for the consumer, but rather for the industry itself producing ready made products, i.e. adhesives, impregnating fluid, plastic and, as in our case, paint and varnish. Thus, the data sheets of the chemical industry giving information on polymerisation, acid value, solubility, viscosity and compatibility with other raw materials, are intended primarily for the chemical processing industry and not for the consumer.

In the chemical industry as a whole there is a clear division between those who produce raw materials, semi-products and finished products. The first two are produced by the chemical industry (i.e. acrylic resins, P.V.A. acrylic and P.V.A. emulsions, solvents etc) which the chemical processing industry then makes into finished products for specific uses, being responsible for the formulation and the testing. It is clear that they seek areas with sufficient financial potential for their branded products.

In order to make the chemical terminology more comprehensible, and because specific types are tested for specific jobs, brand names are often used to identify tested products (i.e. Acryloid B 72, Paraloid, Lucite, Mowilith, Primal, Plexigum A W 2, Ketone Resin N). The unfortunate result of this was that the restorer who lacked a firm basic chemical education, understandably enough when working with the raw materials, from these reports, equated the brand names with finished products (Acryloid = acrylic resin, Melinex = polyester film - just as Aspirin = headache tablet). Whatever was not so named was not to be used. "Acronal" is thus a synonym for acrylic emulsion - but the restorer may not know that there are dozens of types of "Acronal" with all types of possible applications.

But it has not stopped here. With regard to synthetic polymers and especially with acrylic resins and acrylic resin emulsions the development in the last 20 years has been intense because their excellent qualities obtained general recognition, and specific modifications opened up new areas and possibilities of application.

At this time there is a multitude of newer types, new brand names, which in specific applications are better than others, better with regard to solubility, solvent retention, and viscosity. It is also possible that certain resins which were formerly basic types are now no longer made or used, whilst others may still be so. In the field of acrylic emulsions there is scarcely one used today which is more than 10 years old. In the same way manufacturers of acrylic polymers increase and their new brand names and identifications do not figure in the older investigations, thus remaining unknown to the restorer, or because of the synonym syndrome, are perhaps wrongly judged.

In principle the situation is just the same for solvents. Although the basic chemical/physical information is accessible, it is difficult to evaluate it for practical work.

Where then do mistakes mainly occur and what sort of mistakes are they?

Old traditional resins, their application and their behaviour are known best of all. As far as modern materials are concerned, there exist the already cited reports and examinations of the basic types, and also many reports of specific work accomplished. ICOM papers and IIC reports offer proof of their suitability and quality. All of these however deal only with raw materials, as so called finished products from the chemical processing industry (mainly the paint and varnish industry) are seldom made available. In the opinion of that industry the possible consumption in the restoration and conservation sector is too small to cover the expensive costs of development and consumer advice. Furthermore, restorers can obtain these raw materials directly from the producers (or from their agents), when they are then applied by restorers themselves on the basis of information often coming from conservation workshops.

Thus in effect the restorer is only familiar with raw materials or semi finished products; the nomenclature is strange and incomprehensible to him, and thus he is not in a position to form judgements. The results: he is distrustful of new products and refuses them, in the main because the old brand names he knows are synonymous with quality. On the one hand this reaction is both understandable and justified - firstly for purist reasons; the desire to use only that which is known and tested, even if in a specific case it is not the most suitable material - and secondly out of a praiseworthy sense of responsibility, that new products should not simply be used enthusiastically and without reservation. A further factor is that in most studios the practising restorer, for hierarchical reasons, is often not the one to take decisions on the choice of material.

With his modest chemical/technical knowledge of the few tested basic types, the restorer must therefore, for his own purpose, work out the formula for and prepare his own finished product. It is here that the mistakes and failures occur, which can give entire groups and kinds of materials a bad name. These mistakes and failures can arise quite simply out of an incorrect choice of material, or out of the formula devised (choice and balance of solvent, concentration, reversibility, etc.)

Thus the gap between theory and practice arises; clearly the result of the excessive demand made on the restorer with regard to knowledge, familiarity with innovation, formulation and use, nomenclature and material description. The language of chemistry and physics is confusing for the craftsmen/restorers. Or should we expect him, in addition to a large corpus of knowledge relating to restoration, to acquire equally this knowledge of physics and chemistry.

Nobody, restorers included, likes to burn their fingers and thus they, the restorers acquire an antipathy and distrust of all that is new, especially everything that is "synthetic". There is however the other side of the coin, which is dangerous: that new materials are used in an uncritical and enthusiastic belief in progress, sometimes accompanied with an over-estimating of one's own knowledge.

Finally, the antipathy to all that is "synthetic" may also be shown to be unjustified, as indeed "synthetic" resins are made out of natural materials, acquiring through controlled synthesis simply specific qualities, but being also more constant and more pure.

Those, therefore, are the reasons for much uncertainty, lack of clarity, sometimes even perplexity in the restoration sector, when modern materials are discussed.

Solvents are a real mystery for many restorers - and that event with regard to the main types, which may be classified as follows: aliphatic hydrocarbons, aromatic hydrocarbons, alcohols, esters, ketones and ethers. They differ in strength and evaporation time, boiling point or rate, and are divided into weak and strong solvents and low and high boiling solvents.

With regard to the behaviour of solvents there is a tremendous lack of clarity, indeed sometimes a complete lack of knowledge. This is especially so with the use of the so called aliphatic hydrocarbons, the make-up of which is generally unknown. These (weak) solvents are sold under different names in different countries (i.e. white spirit, solventnaphtha, Testbenzin etc) they are not pure products but mixtures. In some cases the name is followed by the fraction = boiling range, in others the content of aromatic compounds, which strongly influence the solvent action of petroleum.

If for example we say that an acrylic resin is soluble in mineral spirit, then we mean a mineral spirit with a specific % (16-35) of aromatic compounds, which supply the solvent for this resin. If this percentage falls below a certain minimum, specifically in weak dilutions, then the resin solution becomes cloudy, or will no longer form a clear shining film.

The restorer often remains puzzled because he does not realise that the careful storage of solvents is also very important. In badly stoppered flasks or polythene containers which are not sufficiently vapour-tight, the lower fractions escape. But these are precisely that part of the solvent that acts as such. Thus white spirit with 30% aromatic, if badly stored, becomes after a time pure high fraction petroleum, having practically no solvent power. This then is the puzzle for the restorer, for, believing he has used exactly the same solvent in the same formula on an analogous piece of work before, he cannot understand why on this occasion it failed. In such a case, it is not the type of solvent which is at fault, but its quality.

Solvents are often sold as brand names (i.e. Shellsol, Aromasol, Cellosolve, Carbitol) with a technical specification, and it is very difficult for the layman to understand such nomenclature in respect of quality. One can on the other hand obtain a chemically pure quality, which is then known by its chemical formula, i.e. ethylene glycol monoethyl ether for cellosolve.

Solvent retention is of great moment as regards success or failure in restoration and conservation work. By solvent retention we understand the resistance to solvent release set up by the resin and/or the ground on which the solvent is applied. This solvent retention is a deciding factor for a certain stage of the work and for certain desired effects. Regrettably the importance of this factor is not sufficiently familiar to the practising restorer. Many failures and material errors may be ascribed to this fact.

Solvent descriptions and scientific papers specify the solvent retention by means of a standard layer of varnish on a glass slide. Even in these theoretically ideal conditions, one can see that it takes a long time for the final traces of solvent to disappear from the layer, and that during this time a misleading picture appears (i.e. of the hardness and

elasticity of the varnish). If, however, this varnish, or more typically, a low percentage resin solution is applied to a paint layer, to penetrate right through the ground, then one realises how long it will take in these more typical conditions, for the last traces of solvent to evaporate from the layers. Solvent traces act however as temporary plasticizers and film forming substances. They thus appear to be sufficient, when in fact that is not the case. The results of this are cracks which may appear months or years later.

Typical examples of this are varnishes of Dammar, Mastic also AW2 and Ketone resin N varnishes, which, it is widely known (but little understood why) have a tendency to brittleness. Some will be then surprised but interested to know, that Ketone resin N was indeed discovered as a binding agent by restorers, but had been intended for quite other purposes by the chemical processing industry, above all as an additive to be used in small quantities (5-20%) for the cutting of lacquer to improve the surface hardness, filling quality and gloss. If then after complete drying Ketone resin varnish becomes brittle, it is not because of the quality of the product, but because it has been used for a purpose for which it has not been recommended. We must note here that Dammar and Ketone resins can be made sufficiently elastic to be usable through the addition of special constant plasticizers.

A further example of the decisive role of solvent retention is to be found in the elaboration of BEVA 371. BEVA 371 is a hot sealant applied in a solvent mixture, which will seal satisfactorily when the solvents contained in it have evaporated completely. If for example the drying time is not held to, or a solvent with too high a boiling point used (i.e. common old white spirit), then the solvent can only evaporate with difficulty from the absorbent textiles or grounds. But pure 100% resin compound BEVA 371 will seal with no problem at 68°C. If any solvent remains however it acts through evaporation as a separator, so that hot tack and sealing power are adversely affected. Thus from unsatisfactory practical application BEVA 371 is noted as a good product, but appears to possess too little adhesive strength.

The choice of solvent is critical when applying synthetic thermoplastic polymers. It is not in practice only a question of which solvent has the best solvent qualities

for a particular resin. One must also take account of the following factors for success: desired concentration, penetration, flow properties, degree of gloss, and above all with spray application, the drying rate, which can only be achieved by a careful mixing of low and high boiling solvents.

When it comes to the formulation of materials for consolidating paint layers, the quickest possible rate of evaporation is desired on the one hand, whilst on the other a good penetration; this last factor can of course be possibly prevented by the solvent evaporating too quickly.

The great problem is therefore to balance the various factors to obtain the best finished product which will meet all the requirements.

However delicate the formulating and preparation of the suitable finished product, so much more so its application. There is still unfortunately too much done by "traditional" rule of thumb, which may not suit the particular situation or the materials used.

Thus the user of modern materials must ask himself: which dilutant is in the present case the most suitable to produce the correct finished product? Here he must also consider the climatic conditions, both meteorological and those of his immediate surroundings. For example, in high summer temperatures with dry air an amount of high boiling solvent will be called for, in order to obtain a perfect varnish film. Similarly, conditions of high humidity will affect the drying rate and the addition of a few% of N-Butanol or cellosolve will often work wonders.

Of the greatest importance, in any case, is the concentration of the varnish or of the impregnating agent. It depends in its turn fundamentally on the composition of the solvent. The choice of material and solvent depends greatly on the work in hand, and above all on the course of the conservation and restoration to be undertaken. Reversibility of employed materials is the guiding principle for sound restoration and thus it becomes the decisive factor in the planning of the work to be undertaken. Certainly, one of the first questions to ask is which types of solvent are unsuitable (i.e. possibly dangerous) for the object being restored. Here of course the solvent evaporation rate is of great importance. Thus for example a strong, or even "too strong" solvent can be used in certain cases because it

evaporates quickly and thus does not endanger the object under restoration. Further one must decide which solvents the paint layers and ground will bear (mineral spirits, aromats, such as toluene or xylene, alcohol or water?) What subsequent work is to take place? Is the ground still in good condition or is it only the paint layers that are flaking?

In practice one will choose a consolidating agent that will not be affected too easily by the varnishes applied later. The concentration of the consolidating agent (% solids per volume or weight) is critical for success. In a well equipped studio with hot table and vacuum, cupping paint may be laid down with a minimal resin concentration, if carried out on a warm table under partial vacuum. Here in many cases excellent results are obtained with the new acrylic emulsions. Not only can they be mixed with water, but also with alcohol and cellosolve, so that the old deformed paint softens at the same time. The addition of traces of surfactants/tension breakers brings deeper penetration. Because they are also thermoplastic after drying they may be lightly sealed under vacuum.

We should note here that too high a concentration or too many layers of adhesive are often used in lining. Present knowledge indicates quite clearly that a minimum should be used. This is equally true of all lining methods which, depending on convention or suitability, may utilise wax resin, BEVA or cold-lining acrylic emulsion adhesives, etc. The minimum meant here is quite clearly that the canvas should not be soaked with adhesive. Thus for example, BEVA 871 diluted with Toluol may be cold sprayed onto the lining or onto a polyester gossamer to form an adhesive interleaf and when it has completely dried it can be sealed without problem. In the same way wax resin compound may be applied to silicon paper at 60°C on the hot table, then transferred to the canvas and sealed afterwards. Acrylic emulsion adhesives can be also transferred and sealed as above. As regards cold lining we should like, above all, to call attention to V.R. Mehra's method.

An unfortunately widespread fallacy is the belief that an adequate finished product may be produced simply by making a solution of a modern synthetic polymer in its corresponding solvent. But within reasonable limits it is neither the type nor the choice of basic resin that is as critical as the delicate art of formulating and preparing varnishes, and

having the right combination of low and high boiling solvents, and additives such as surfactants and flattening agents. Above all one must realise that acrylic emulsions supplied by the chemical industry are not finished products; they need additives like protective colloids, tension breakers, Biocide, coalescing agents and exact pH value adjustment, in order to become effective materials for conservation.

Modern consolidation and lining of pictures requires, without doubt, cleanliness and reliability in the studio (tidiness, no over-stocking of materials) as well as suitably designed tools and apparatus, which in turn presuppose the dexterity and ability of the restorers to use them.

The point of this paper is to show how important it is for today's restorer to realise that knowledge of the few tested raw materials and semi finished products is now no longer enough for reliable work. These materials must be applied as products which fit the job in hand; they must be correctly processed, and this calls for a certain degree of knowledge of chemistry and physics. The question then is: can we demand such knowledge of a restorer, bearing in mind that he must already amass so much knowledge in his own field?

We believe that there are possible solutions to the problems we have elaborated but that they are not simple. We would therefore recommend the following course of action to restorers:

- Locate the few manufacturers of finished products who concern themselves with restoration problems. Only they can supply the correct information as to which products are suitable for particular purposes, and how they can be formulated and applied.
- There is no doubt that conservation training institutes and studios should no longer restrict themselves solely to the basic investigations but should likewise locate the chemical processors in question, be more open to new developments and communicate fresh knowledge and investigative methods to their students. One must be at one and the same time critical, but not reject new developments a priori.
- Fundamental research and analytical testing are no longer within the realm of practising restorers, but they can make a contribution towards the acceptance and value of new developments: They can carry out critical and practical tests with new materials on the basis of information supplied by the processing industry, only these tests will give restorers clear information on whether the new materials really do represent progress and advance their technical knowledge and capability.

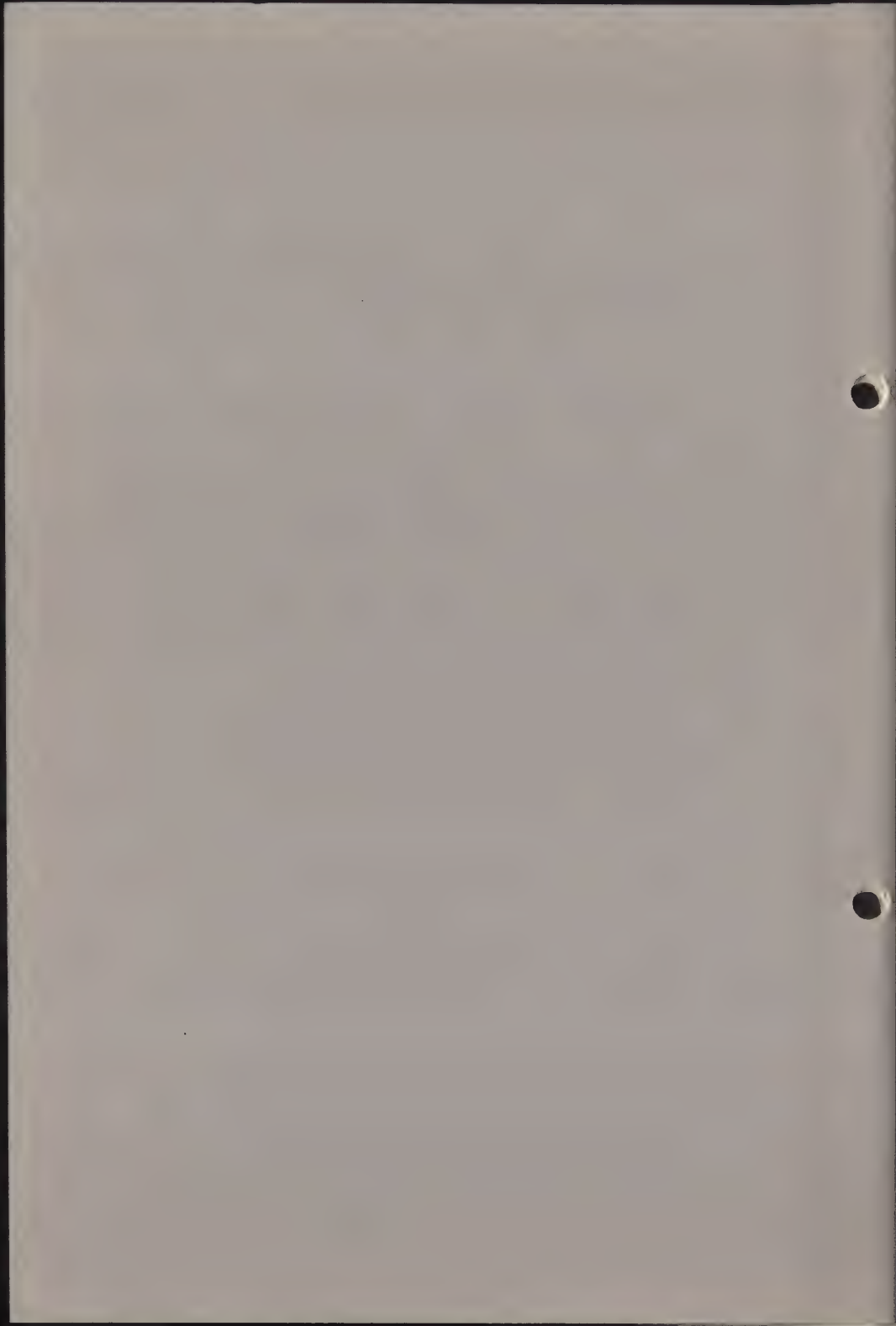
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ENZYMATIC CONSOLIDATION OF PAINTINGS

Frantisek Makes

ICOM Committee for Conservation
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Working Group: Structural Restoration of
Canvas Paintings



ENZYMATIC CONSOLIDATION OF PAINTINGS

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Abstract:

This Paper describes the weakened state of the paintings in Skokloster Palace and their conservation. The damage to the fabric supports of the paintings caused by the cellulose hydrolysis had created differences of adhesion between the paint layer and the canvas. The hydrolysis which was going on in the canvas caused the paint layer to flake off in several areas. The cellulase activity of the molds present, especially from an old culture, was found to have its optimum in the range of pH 5.8 - 6.5. The acid surface of the canvas and the varying temperature at Skokloster Palace was found not to influence considerably the cellulase activity. This was on the other hand most affected by the presence of a new paste.

Introduction

Skokloster Palace has been preserved generally unchanged since the 17th century. The temperature drops indoors to under 0°C during the winter months. The relative humidity in the corridors and rooms of the palace is very high, up to 100%, and is subject to great variations in the course of a year. In the palace several collections of different antiquity objects are preserved such as paintings, tapestries, drawings and so on. The preservation of these old paintings depends on an adequate restoration. In this collection there are some paintings which have not yet been restored, some which have been restored during the 18th century and others which have been restored in the years up to our time.

This makes it possible to study both the materials used for restoring purposes and the original painting materials whose degradation has been hastened by the high relative humidity. It has been proved that the breakdown of the materials used for restoring purposes affects also the decomposition of the whole painting. The breakdown is primarily caused by the enzymes of the micro-organisms present in the paintings. This process is going on in all paintings and in all locations, whereas only its reaction rate is different in each case, owing to varying external conditions. It would be wrong to think that such reactions are going on only at Skokloster Palace. But since at Skokloster Palace these reactions are remarkable and occur in relatively a short time, it is easier to study them there, than somewhere else. Lining does not stop this reaction as I have proved in my book quoted below (1). Restorations done in the last years at Skokloster Palace by traditional handwork techniques has unfortunately only hastened this degradation, bringing about extremely great damage in the paintings.

The incomplete mechanical removal of old pastes has left some remnants of it on the original canvas. By addition of new pastes the biological activity of the micro-organisms present there and their reactions has been increased. The paint layers of the pictures have flaked off and, at the same time, molds have grown through the canvas and later penetrated through the whole paint layer. The enzymes involved in these reactions have damaged the original canvas to such an extent that in some areas only the ground of the picture has been left. By examining the paintings which have never been lined I have been able to establish that paintings at Skokloster Palace prior to 1650 do not have any proteinaceous isolating layer between the canvas and the ground (1).

The paint layers in these pictures are undamaged, whereas their canvas supports often have been damaged. These pictures need first of all a restoration of the canvas. Unfortunately by a wrong evaluation of the need of adequate restoration some of these pictures have been lined using a paste adhesive. As a consequence of this treatment the paint layer has flaked off and molds have become apparent.

My study has proved the necessity that restoration techniques have to take into consideration following aims:

- (a) To pay regard to the point of view of the history of civilization.

The artistic identity of each painting has to be established by preserving the nature of the painter's brushwork as well as the painting's colours.

- (b) To pay regard to the technical structure of the painting and its materials.

Every restoration has to follow the painting's structure and to preserve its old materials unaltered as well as its old original canvas.

- (c) To pay regard to and accept the changes brought about by the painting's natural aging.

The painting's own character has to be preserved together with its cracks.

- (d) To respect the real state of the painting.

It is extremely important to keep alive the feelings about the painting's importance in its historical context. An old painting has been created in a different environment than our one.

Restoration

This picture has been painted by Matthaeus Merian in 1651 on a canvas. The ground consists of ochre and oil. No isolating materials of protein nature could be detected, during the investigation. The paint layer had flaked off and many spots are present on the canvas. Some losses were filled by means of cement composed of chalk, protein and white lead. The fillings were overpainted with paint mixed with adhesives. No oils or disinfectants could be found in this overpainting. The old final varnish of the picture consisted of egg-white and oil.

Varnish and overpainting

Removal of this varnish proved to be necessary in this case. On some areas the varnish had deteriorated and showed some small cracks. The varnish contained some lipases that affected the oil present in the varnish. The activity of the lipases were examined titrimetrically. The optimum pH of the lipases varied between 7.0 and 7.5. By changing the pH the enzymatic activity did not cease, but decrease to about 50% at pH between 6.0 and 9.0. The enzymatic activity was assayed, temperature was at 30°C. Therefore, it was suitable to remove the egg-white present in the varnish by means of Pronase E at pH 7.0 - 7.5. The hydrolysis of the lipases hastened the removal of the varnish. The removal of the varnish from the paint layer was brought about by means of the enzyme Pronase E (2), which was immobilised on cellulose. The diffusion to the paint layer took place very slowly. The products of the fractured varnish coloured the bearer, so that the whole process could be followed. The Pronase E was dissolved in a 0.07M phosphate buffer, pH 7.4 at 20°C. The removal of the varnish took 30 mins., those of the overpainting and cement 70 mins.

In order to assure that enzymatic reaction occurs exclusively in the areas of the picture and not elsewhere a specific solvent mixture must be used. It is of great importance to choose the right nature of such mixture. (3).

In this particular case, the following solvent mixture was applied on the reverse of the picture (benzine, turpentine and ether 4:1:5) at 20°C. in order to protect the canvas.

Canvas

The original canvas consisted of 3 pieces that had been sewn together. During the 18th century some strips of new fabric were sewn on the edges of the canvas; in many areas the fabric was pasted together by means of paper and on other areas by means of another type of fabric. As adhesive for the fabric strips glue and flourpaste has been used on some areas and glue and honey on the others. Paper had been pasted by means of casein. Moreover, it was found that the fabric substrate contained carboxylic acids: oxalic acid, citric acid, tartaric acid, amber acid and lactic acid.

The pH had some different values in the fabric:

In strips sewn on the canvas during the 18th century	pH 4.9
In strips pasted by means of paste and meal	pH 6.6
In paper pasted by means of glue	pH 5.8
In the original fabric	pH 5.0

Some molds were observed by means of UV light in the original canvas. These micro-organisms were found by SBL (State Bacteriological Laboratory) Stockholm to be a *Aspergillus* sp. Two enzymes able to split the cellulose were detected as products of these molds. These enzymes were separated by means of thin layer chromatography. Their cellulase activity was closely investigated as a function of several substrates. The cellulases were isolated from the molds and examined. The molds were incubated on Metocel, Sabouraud and starch as substrates (I. Mares SBL). The bulk of the mycelium was removed from the substrates by filtration and centrifugation and culture filtrates were used directly in order to determine the enzymatic activity.

Cellulase activity

The cellulase activity measured photometrically (4) and polarographically (5) was found to depend on the ion concentration in the water solution. The optimal activity of these two cellulases was observed in the small area of pH 5.8 - 6.5. When the pH values moved from the optimum area to the acid one by about one unity, the enzymes still showed an activity of 70%. When the pH values moved further to 3.5, the activity diminished rapidly by 10%. When the pH values moved to 7.0, the activity was 80%, even if it had been dropped very fast. At pH 7.5 the activity was 50%. When the pH values increased by one unity to 8.5, the activity dropped to 20%. The intensity of the enzymatic hydrolysis of the cellulases in the culture filtrates was determined at different temperatures. The intensity of the degradation of the enzymes was found to increase by increasing temperature up to more than 40°C. After 45°C the enzymatic activity decrease very rapidly. It was noticed that 35°C was the optimal temperature.

Evaluation of the cellulases

It was interesting to observe that the above investigation proved that optimal growth of the molds and their enzymatic activity needed pH 5.8 - 6.5 and that changes of pH values could be tolerated within a wide area of pH 3.5 - 8.5. The paste was found to give optimal pH values for the cellulase activity. The acidic surface of the original fabric was found to have only a partial effect on the molds enzymatic activity. At Skokloster Palace the environment temperature increases in May and June to 15 - 20°C, the relative humidity being 50 - 60%. Owing to the hygroscopic nature, the paste maintains a high relative humidity which is an essential condition for the molds activity.

Glue (paste)

For removal of the strips pasted by means of meal and paste I used an enzyme - amylase (6) absorbed on cellulose in a phosphate buffer at pH 6.9 and 20°C. During these investigations the hydrolysis developed rapidly, and the pH values in the buffer 6.9 and the old paste pH 6.6 remained nearly unchanged. Notwithstanding it was necessary to remove the remnants of the paste which had penetrated the fabric up to the ground by means of another enzyme because the buffer used for the - amylase constituted an optimal condition for the cellulases in the original fabric, too, that could also damage the original fabric.

For the removal of the remnants of the paste I used trypsin (7) absorbed on polyvinyl alcohol in a buffer at pH 8.5 and 20°C. The cellulase activity was found to be 20% on these conditions. The removal of the greater part of the paste took 25 mins., the rest of the paste took 10 mins. In order to isolate this enzymatic reaction from the paint layer I used a mixture of wax and turpentine (1:10).

The removal of micro-organisms as well as their enzymes from the original fabric was the absolutely most important aim of restoration in this case. During the investigation of the cellulase activity it was found that the cleaning procedure had to be carried out at the low pH value of 5.0. The cleaning was carried out using a

mixture of organic solvents, water and an emulsifier. In this way the enzymes' activity was inhibited. The removal of the cleaning mixture and the enzymes was brought about by means of cellulose powder. A second cleaning was carried out using Sepharose. The sublimate was used in order to bring about an irreversible inhibition. The damaged canvas was impregnated with an acetylic solution of 2%.

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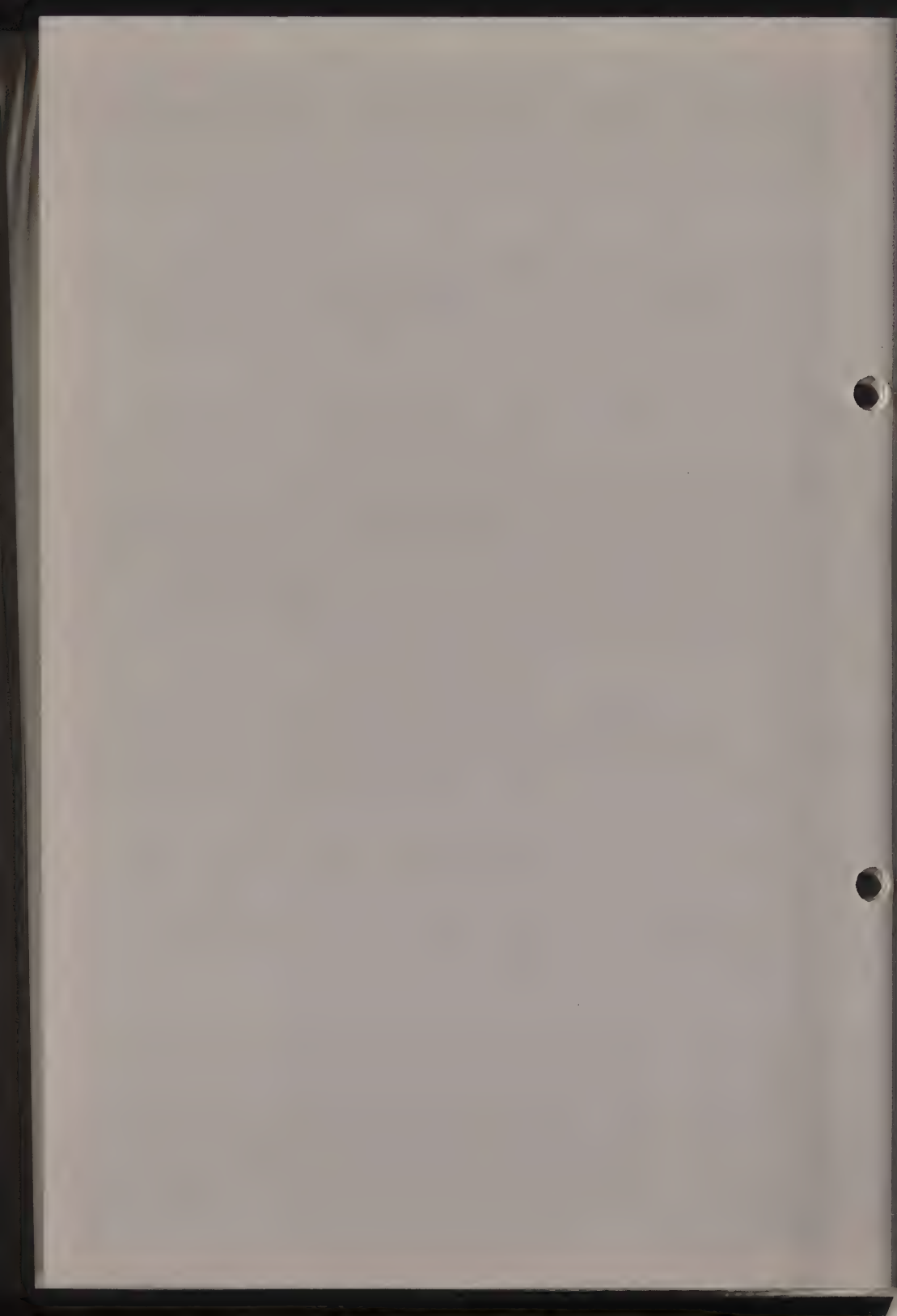
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LOW PRESSURE - HEAT, MOISTURE, STRETCHING.
NOTES ON FURTHER DEVELOPMENTS

Bent Hacke

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Structural Restoration of
Canvas Paintings



LOW PRESSURE - HEAT, MOISTURE, STRETCHING. NOTES ON
FURTHER DEVELOPMENTS

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ABSTRACT:

This contribution is a continuation of the writer's article "A Low-pressure Apparatus for Treatment of Paintings" published at the ICOM Committee for Conservation, 5th Triennial Meeting in Zagreb in 1978.

The article describes the development of the apparatus and method during the past three years. The apparatus has undergone technical improvements, and the method have been adjusted on basis of experience.

The apparatus offers possibilities of treatment of paintings with heat-moistening, pressure and stretching. Some experiments have been made with the regenerating of organic glue in the original material, and new knowledge has been gained as to the treatment of graphics and textiles. Further more a mention is made of some new possibilities of treatment of glue-lined paintings.

In order to understand the content of this article completely an acquaintance with the previous article is necessary.

Introduction.

At the ICOM Committee for Conservation 5th Triennial Meeting in Zagreb in 1978 I introduced a low-pressure apparatus for treatment of paintings, which has been developed, constructed and for several years used in the daily work in our conservation department. Apparatus and method were described in the article "A Low-Pressure Apparatus for Treatment of Paintings", and furthermore a film shown at the congress illustrated a course of treatment.

The article and the film described some of several possibilities of treatment as well as our plans for further development of apparatus/method.

Since then the experiments have been carried on, and considerable improvements have been achieved. Technically the apparatus has undergone radical changes, whereas the methods have not changed proportionally, but based on our experience an adjustment has taken place.

As the School of Conservation of the Royal Academy of Fine Arts in Copenhagen was very interested in acquiring two low-pressure tables for educational purposes, and as our own apparatuses, which were manually constructed, showed traces of many years of wear and tear, we decided to have a number of tables of high quality industrially manufactured. At the same time we had possibility of improving the system.

In the summer of 1979 a number of apparatuses comprising these technical improvements were finished. Made of stainless steel and aluminium they are built as large practical mobile tables. The upper part is the low-pressure apparatus itself. The bottom part consists of a sound-proof supporting cabinet holding an industrial vacuum-cleaner, a humidifier, ventilators, channels, electric installations etc.

We have with these apparatuses obtained a tightness and an efficiency, which have not been obtainable in the previous wooden apparatuses, and the high quality provides in itself a better safety and precise possibilities of control, which directly improve the results and extend our possibilities of treatment.

Technical improvements.

As mentioned in my previous article one of our plans in connection with the development and improvement of the apparatus was to connect a humidifier to the apparatus itself thus enabling us, as a substitute for or a supplement to the application of moisture by evaporation when flattening a painting on canvas, more precisely to control and dose the moisture of the painting during treatment. Therefore, we decided to prepare the new apparatuses for the connection of a humidifier including channels, moisture chambers etc. As I also mentioned in my article we had carried out a series of experiments with a humidifier connected to the low-pressure apparatus. Based on these experiments and calculations a humidifier has been constructed, fitted and built into one of our large apparatuses, where it now has been working on the experimental stage for about one year.

Another major improvement is, in our opinion, the introduction of a strainer frame fitted into the upper part of the apparatus. In this strainer frame the painting is mounted, and by means of a screw spindle system it can slowly and evenly be stretched when at the same time working with a plastification of the painting by means of moisture and solvents using vapor treatment.

The new apparatuses are, like the previous models, fitted with a top frame, to which the painting is attached. However, this top frame has proved to be too heavy in our larger tables, and we have come to the conclusion that a strong, laminated wooden frame is easier to handle.

This frame is only taken into use, when aqueous adhesives are applied in the treatment.

The use of the strainer frame and the top frame created a new problem. In order to establish a pressure on the painting it was necessary to cover both the painting and the frame with Melinex polyester film thus preventing the air flow from passing through the frame system. As we still consider it important to avoid covering the surface of the painting, we have to improve upon the apparatus. A blind system is now mounted on all four sides of the apparatus permitting a thin piece of oil cloth to be pulled in over the frame and the edges of the painting. In doing so a tightness is achieved outside the painting, and the necessary pressure on the surface of the painting can be established without cover. This system can, of course, also be applied, when synthetic resins are used for impregnating and lining, which make the mounting of the painting to the top frame in most cases unnecessary, but it is not applicable when using moisture for flattening or when using aqueous adhesives for lining, which necessitates the mounting of the painting on the frame.

Other substantial improvements.

In order to control the pressure we have installed:

- a) an adjustable air valve connected directly to the air channel and
- b) an electric regulation mechanism directly connected to the motor of the vacuum-cleaner.

We choose to built in both control devices, as they both have their advantages.

The electric regulation mechanism is able to control pressure very precisely, it is for example possible to establish a pressure as low as 2-3 millibar and keep it throughout the treatment. The air valve, on the other hand, does not provide the same accuracy as does the electric regulation mechanism, but it is able satisfactorily to control the air flow blown into the system by opening the valve.

The air valve will mostly come into use in cases, where it is considered necessary to shorten the drying process due to treatment with moisture or aqueous adhesives, and an increasing air circulation therefore is desirable.

As described in my previous article we always use a support under the

back of the painting in order to prevent even a slight pressure from changing the surface structure of the painting.

We have considered it necessary to have a wide range of supports differing from each other as to thickness, density, structure, absorbing capacity etc. To each apparatus we have made a number of supports, which, when not in use, are kept in plexiglass tubes, which are mounted to the apparatus. The supports are selected according to the object to be treated.

The wide range of supports has reduced the importance of changing the metal sheets according to the individual treatment.

The new apparatuses have brought us closer to our goal being the construction of a solid and reliable instrument enabling us to use, control, and vary the factors that individually or together have been used for reinforcement, flattening, and lining of paintings on canvas.

These factors are, in our opinion, the following: pressure - heat - moistening - stretching.

To each of these factors we have imposed certain conditions, which we try to meet.

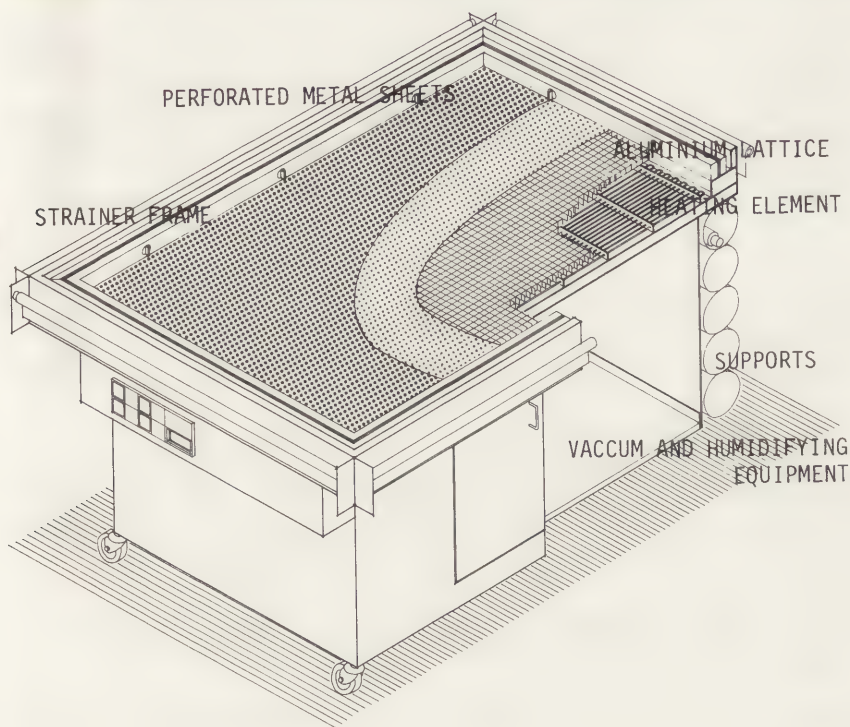
Pressure: It should be as low as possible.

Heat: The temperature should be as low as possible.

Moistening/
Plastification: Should preferable be done by vapor treatment using water and organic solvents. The use of solvents should be restricted to a minimum.

Stretching: Should only be applied as a weak, evenly stretch and usually in connection with vapor treatment, and only after consolidation of the structure.

WORKING TABLE - UTILIZING LOW PRESSURE, HEAT, MOISTURE, STRETCHING.



Treatment, tests and results.

The developing of the treatment has been closely connected with our daily work. For several years we have had the opportunity to use the apparatus in treatment of a large number of paintings. Thereby we have gained a wide experience, which has formed the basis of the adjustment and development of the methods, which have taken place in the past three years. The most important of these will be mentioned here:

Pressure.

In our previous tests we attained to establish, under normal conditions, a pressure at approximately 500-1200 mm W.c. Today we use a pressure at approximately 200-500 mm W.c. with results just as satisfactory as before and without prolonging the treatment and without increasing the risk.

We have realized that the pressure applied till now was higher than necessary.

At the same time the changes in methods have made it possible to reduce the pressure even more. The combination heat - moistening - softening - pressure - stretching has made the pressure less important and therefore it can be further reduced.

Heat.

We still consider heat an important factor, when flattening and impregnating paintings with deformities such as cracklings, bulgings, tears, etc. First because heat is necessary for efficient vapor treatment and second because heat itself often plasticize the paint-layer. We still operate at a maximum temperature of 450°.

Moistening/Plastification.

Our experiments with moistening of paintings by evaporation, which were described in details in my previous article, have been carried on and have come to play a much more important role than before. Today moistening is applied for the treatment of about 70-80% of all paintings with deformities, repaired in our conservation department.

We have tried to perfect this treatment in several ways:

- a) by measuring the amount of water used for moistening (evaporation) we have tried to establish an individual dosing according to the material to be treated. In continuing our experiments we hope we shall be able to evolve a method for dosing, though it often will be subject to some uncertainty. This method of moistening by vapor treatment is, in our opinion, the greatest progress since the construction of the apparatus, as the combination low pressure/low moistening normally yields good results within a short period of time.
- b) due to our great interest for the application of moisture in the treatment we decided, in 1979, to connect a humidifier to the apparatus. The installation of the humidifier must be regarded as an attempt to improve and supplement this method thus enabling us more precisely to control and dose the inflow of moist air into the system during the treatment of the painting. It proved to be very complicated to work out a system which makes it possible to blow in moist air which can be accumulated in the structure of the painting. But after years of experiments we think we have succeeded in solving the problem relatively well, and it is now possible by means of the humidifier to carry out a controlled moistening of the painting. As the treatment of paintings is concerned

the method has not proved as good as the method of moistening by evaporation, but it seems to be applicable for treatment of graphics. We do not quite understand this difference, but we presume that an increase in the capacity of the humidifier and a few minor technical modifications will solve the problems.

Ethylene glycol mixed with white spirit and sometimes added water is normally used to plasticize the structure. It is applied by spraying or by evaporation.

Stretching.

As it appeared from my article we have worked quite a lot at stretching by means of paper pasted on to the edges of the painting, e.g. stretching on a moistened board as a preliminary treatment for the further treatment in the low-pressure apparatus. This part of the treatment has been extended with the introduction of a strainer frame fitted into the upper part of the apparatus. The introduction of the strainer frame to the system has extended our possibilities. The apparatus/method can normally repair most paintings with cracklings, bulgings, etc., whereas the strainer frame is applied for more complicated cases with serious deformities in the surface. In such cases a stretching combined with a normal treatment has proved to be very advantageous and has yielded good results.

We are considering using the strainer frame in most treatments, believing that a light stretch combined with the normal treatment might ensure a longer durability of a treatment.

Remarks.

As it appears from the description of our experiments and results in 1978, we consider the plastification/flattening process the most important part of the treatment. This implies that we often finish our treatment after the flattening, the impregnation, and the stabilizing of the canvas and paint film and therefore do not continue with the lining, but finish with the strip-lining and the mounting of a canvas loosely attached to the back of the original canvas and perhaps with another special protection of the reverse side of the painting.

This development has continued as a logic result of the possibilities which the apparatus and method offer to remove tensions in the painting and to consolidate the structure.

Regeneration of paste-linings.

Combination of heat-moisture and pressure makes the method very suitable for regeneration of paste-linings for instance when a removal of the paste is considered risky. However, it is a condition that the paste is not too old, desintegrated or hard. - Stretched on the wooden frame and exposed to treatment with pressure moisture and heat it is often possible to regenerate the paste-layer, prolong the durability of the lining, and at the same time to make a flattening of the surface. It should be pointed out that due to thickness, hardness of the paste-layer as well as the texture of the lining canvas the flattening can only in few cases re-establish the original surface texture.

The removal of paste-linings.

The apparatus has proved to be useful for the removal of old paste-linings where water or paste are applied for softening the paste-layer, some moisture is accumulated in the canvas at the risk of movements in the canvas and damage to the paint film despite facing and other precautions.

This kind of work can be carried out directly in the apparatus if the painting is mounted to the frame while removing the paste. If a partial flattening is desirable due to bulgings or other deformities or as a matter of precaution the painting is covered with Melinex and pressure and heat established, and the moisture will soon be removed.

When the paste-layer is completely removed a flattening and stabilizing can be carried out. Normally it is not necessary to renew the lining, and the treatment can be finished with a strip-lining and mounting on a stretcher with backing.

Treatment of paper.

We are no experts on treating paper, but we have been asked to carry out restorations in this field as well. We have used the apparatus for treatment of a large number of modern graphic works, some of considerable size and with very difficult and fragile surfaces (Jorn, Fontana, Warhol, Hockney etc.). Furthermore we have treated gouache tempera and watercolours on paper.

The graphics are all treated on a special polyethylene sheet with a smooth surface and which is permeable to air and moisture. This sheet is placed on top of the perforated metal sheet of the apparatus.

Our results have been unexpectedly good. Using very small quantities of moisture and low pressure and heat (30° C and 300 mm W.c.), it has been possible to flatten and remove large deformities in both paper and colour.

The moistening is normally applied by the humidifier or by evaporation or simply by rubbing the surface of the polyethylene sheet with distilled water. Furthermore the moistening can be effected by spraying the back of the paper, provided it does not damage the object. - A treatment can be finished within 3 hours, when applying small quantities of moisture. It is a necessary condition that the pressure is not interrupted while the object is moist. The apparatus can also be used for mounting of graphics on paper by application of aqueous adhesives. In such cases the apparatus acts as a press at the same time as it removes the moisture. Generally speaking the paper regains its original flexibility and the colours their original brightness.

The low pressure together with the possibilities of avoiding covering also permit treatment of graphic art which has relief standing out of the surface. Recently we succeeded in treating a series of graphics by L. Fontana with relief in the surface without altering the original structure.

Treatment of textile.

We have also had the opportunity to treat textiles. One of our asso-

ciated museums acquired a number of painted quite large cotton canvases from Bali.

The painting was executed directly on the canvas in gouache technique. The canvases were made of several pieces and canvas as well as paint film were disintegrating.

These textiles were treated on the apparatus. The flattening was carried out according to the directions for treating paper. In this case we came up against a special problem as the canvases were larger than the apparatus. By means of some large rolls along the sides of the apparatus we succeeded in accomplishing the treatment.

In this case as well our results were far better than expected. We succeeded in re-establishing the original surface structure of the canvases as well as impregnating and fixing the disintegrating paint film.

For further protection the canvases were lined on a very thin fine-woven polyesterweave. This adhesive for the lining was a mixture of Plextol D 541 and Plextol D 360 (acrylic-emulsions) in the proportions 1:1. For impregnating was used Plexisol P 550 (acrylic resin.) dissolved in white spirit (30% solution).

Regeneration of organic glue in the original material - addition of organic adhesives.

It is our experience that the apparatus/method to some extent make it possible to regenerate the glue in the canvas by applying heat and moisture. In some cases it even has been possible to fasten flaking paint and to stabilize original structure without adding adhesives.

The durability of such a treatment is still an open question. We have treated a number of paintings in this way, they are now back in the museums where they are exposed to different conditions and kept under observation. So far they have not shown signs of instability, but it should be stressed that the observations only have lasted for a few years.

Furthermore we have experimented with the adding of organic adhesives such as animal glues and gelatine to the painting, but we feel that we skate on thin ice finding it very difficult to decide how to dose the adhesives.

An overdosing of a hygroscopic adhesive can easily interrupt the balance of the structure of the painting in a negative way and make it more sensitive to changes in the humidity not to mention the danger of a microorganism attack.

However we believe that there are potential possibilities to be investigated. If the stabilizing of the original by using organic adhesives is to succeed, we consider a co-operation with chemists as well as further tests a necessity.

The possibility of finding solvents which are able to regenerate glue in the original material without affecting the structure, should not be excluded.

Adhesives for impregnating and lining.

As described in my article from 1978 organic adhesives and paste were

to some extent used in our department. It was also mentioned that it was our goal to replace them by synthetic adhesives, primarily because we consider the hygroscopic properties of the organic adhesives to be of negative influence. - According to our investigations made in co-operation with chemists we have, as many of our colleagues, introduced the use of acrylic resin for impregnating and lining. The major part of the paintings needing impregnation and lining are treated with Plexisol P 550 and Plectol D 360.

These adhesives are used according to the lines laid down in the article from 1978. However, a minor modification has taken place, now we apply thinner layers of Plectol D 360 for lining, normally 1-2 layers as opposed to earlier, when we used 2-3 layers. This is mainly due to the fact that the relaxation of the original structure obtained during flattening in most cases makes strong support unnecessary.

We shall not go into further details concerning the properties of the synthetic materials, but only point out that they satisfied our demands for resistance adhesive power and reverseability. We have for some years had opportunity to observe paintings, which have been treated with these adhesives, under various conditions. At regular intervals we examine the paintings and generally they have proved resistant to heavy strain. Even after several years they need be stretched. But it should, of course, be pointed out that that is not only due to the excellent properties of acrylic materials, but perhaps more to the combination of methods and the use of acrylic materials.

In order to extend our possibilities of increasing the stability of our treatment we have replaced the ordinary canvas by a polypropylene-weave for lining and a polyamidweave for backing. We still use paste-linings, but to a smaller extent than before and mostly for treatment of modern paintings with serious crackling large deformities in paint film with impasto. In these cases a flattening often proves insufficient and therefore the support of a paste lining is necessary.

Postscriptum.

It is difficult exhaustively to treat both method and apparatus in a short article like this.

We would prefer to show our colleagues how we work in our department and maybe get inspired or perhaps inspire to develop our work.

We hope that it has appeared from this article together with the one from 1978 that it has not been our goal to construct a machine to solve our problems, but to construct an instrument based on the tradition of our profession. As always the success depends on the experience, skill and capability of the person using this tool and its possibilities.

In our opinion the hot-table with its violent heat and pressure stress when applying wax-resin to the original material was not only a false trail, but also a violation of a very old tradition, which until the introduction of the hot-table had undergone a slow and natural evolution.

We think we ought to go back to this tradition, but of course use some of the possibilities, we are offered by the modern technology. Fortunately a lot of our colleagues are seeking back to this tradition to find a starting point for the use of modern technology. Common for these efforts are that the original material should be treated as little as possible and the protection of the works of art be given greater priority.

We approve of these efforts and shall continue our work accordingly and willingly in a closer co-operation with our colleagues.

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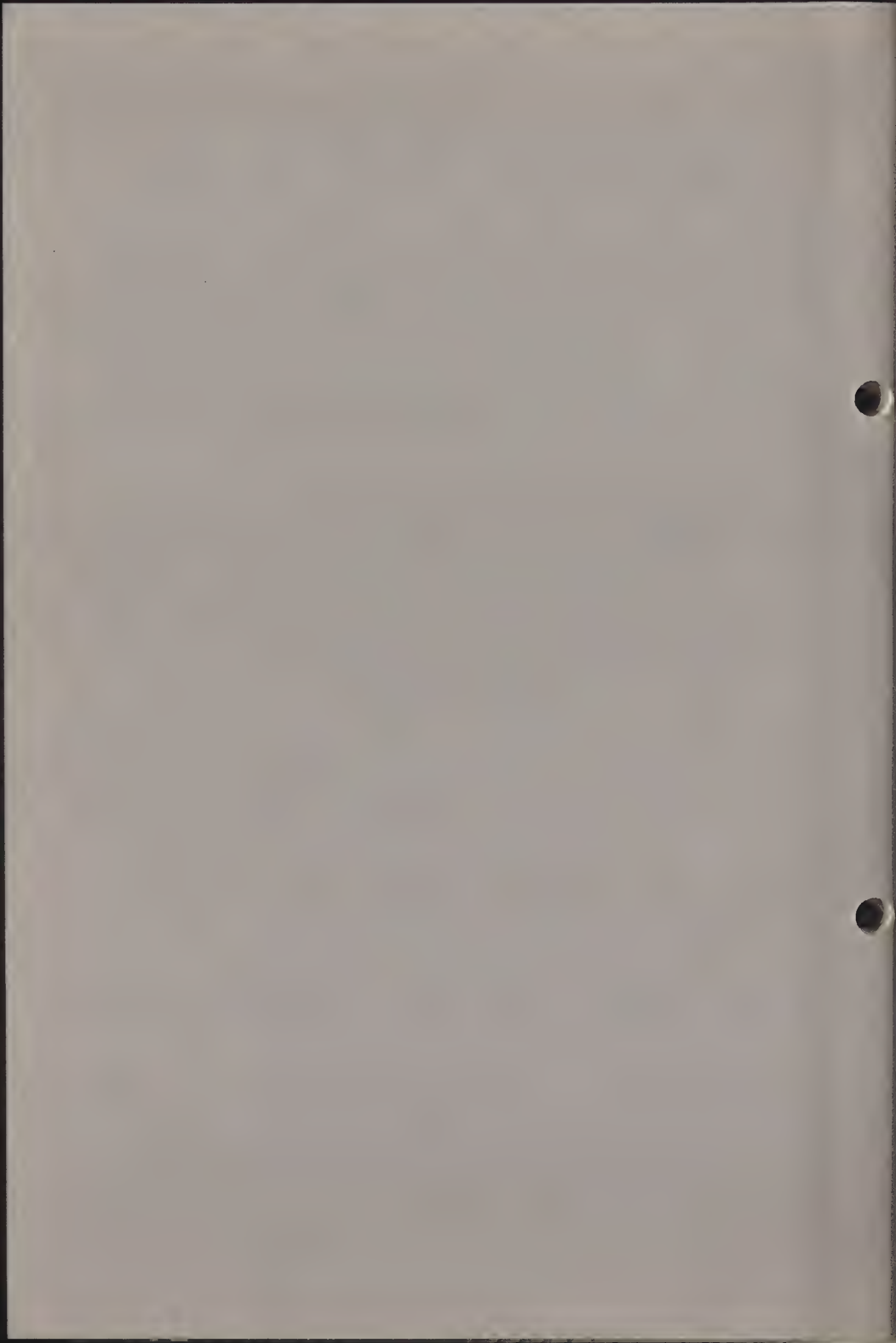
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FLATTENING, CONSOLIDATION AND IMPREGNATION
OF PAINTINGS IN THE ROYAL MUSEUM OF FINE
ARTS, COPENHAGEN

Mette Bjarnhof

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Structural Restoration of
Canvas Paintings



FLATTENING, CONSOLIDATION AND IMPREGNATION OF PAINTINGS
IN THE ROYAL MUSEUM OF FINE ARTS, COPENHAGEN

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Abstract.

This article sums up experiences made in the conservation department in flattening and consolidation by treating in four years more than 200 paintings. We use a low-pressure apparatus, developed by Bent Hacke, and to this we apply moisture and organic glue to preserve the identity of the materials, which is for us a basic principle. We make a clear distinguishment between consolidation and relining. Further, we give a description of the functioning of the low-pressure apparatus as well as the flattening, and impregnation process, and how we combine supporting canvas and striplining. Lamination folio is mentioned too, and also the regeneration of paste relining in the low-pressure apparatus or on the hot table.

The Complexity of Problems.

For several years the conservation of paintings in our museum has been made with a wish to preserve the identity of the material. This means that materials are chosen which are compatible with those of the painting or resembling them as much as possible. Moreover, the materials must be reversible to make a future treatment of the painting possible.

In recent years many new synthetic materials, which are gradually gaining ground within the painting conservation, have come on the market. Several of these materials are exceedingly well suited for special purposes such as laminations or temporary working processes. As they are time-saving, many conservators may be tempted to utilize them. However, using them for impregnation of paintings does have its problems.

In an air-conditioned museum, regularly supervised, impregnation with synthetic materials should only be made in special cases - except for those of quite modern paintings. The reason why great care is necessary is the continuous

appearance of new and better synthetic adhesives. So, in future many pictures will have no clear structure, if the latest product is to be used in repeated treatments of a picture. Frequently a conservation process has to be abandoned, when the painting has previously been impregnated with a consolidating material, inconsistent with what you would prefer to-day. Most of the materials recommended are claimed to be reversible, but experience shows that this is only partially true, as in many cases you have to use very strong solvents, possibly damaging the painting.

We already know the problems from a great number of previous wax relinings. This method was introduced, because it was regarded more stable than the traditional paste relining, and especially the introduction of the hot table has unfortunately caused a great number of wax relinings. To-day many of these relinings must be renewed. However, it turns out to be almost impossible to remove all the old wax, in order to apply a different method.

This is why we have found the use of moisture and well-known adhesives like sturgeon glue and gelatine preferable. Over the years the applicance of organic glue for conservation has been much discussed. The historical development has been described by W. Percival-Prescott in "The Lining Cycle" (1).

Many kinds of glue have been thoroughly tested in our museum, and at the present time sturgeon glue and gelatine are preferred. Admittedly, glue will decompose in the course of time, but reasonably used, it forms a natural part of the painting, and in this way the original structure can be maintained. Another reason why glue is preferred is that it does not alter the painting optically.

One of the objections to the use of organic glue is that it is easily attacked by micro-organisms. However, in connection with paintings in modern museums this drawback is to-day negligible. In the course of time the use of aqueous adhesives has caused many failures, ranging from the shrinking of canvas to the tarnishing of paint.

Nevertheless, owing to the low-pressure apparatus (2) moisture together with organic glue is preferred to-day in our museum. This apparatus permits the utilization of the good qualities of the glue, and at the same time it eliminates the drawbacks.

Consolidation - Relining, Two Separate Processes.

Traditionally, consolidation and relining was one process, comprising fixation of the paint layer as well as the flattening and attaching of the new canvas. To-day flattening and consolidation are considered a problem in itself, in fact it is the most essential part of the treatment. After the flattening and the consolidation you

must decide whether further striplining, the addition of supporting canvas, or a relining would be necessary.

The Low-Pressure Apparatus.

In our museum we use a low-pressure apparatus, developed and described in detail by Bent Hacke (2). A film describing this apparatus was shown at the ICOM congress in Zagreb in 1978.

Functioning of the Apparatus.

The principle of the low pressure apparatus compared to that of the hot table: In the low-pressure apparatus a constant, homogeneous suction is generated under the whole picture by a vacuum cleaner so that a low-pressure is created. On the hot table there is a single exsuction tubing, and a pump generates a vacuum. However, the low-pressure produces a gentler course of treatment.

In the low-pressure apparatus possible moisture is carried away by the air current, which amply penetrates the picture. Complete drying can take place rapidly, while the picture is under pressure. On the hot table, however, possible moisture is encased, and to remove it the treatment will have to be interrupted. - This means that in the low-pressure apparatus aqueous impregnation materials may be applied without causing damage. The pressure in the low-pressure apparatus is varied from a gentle to an effective suction. The latter can be obtained by covering the surface of the box with a piece of melinex (3). Besides, the pressure can be controlled by means of a slide resistor connected to the vacuum cleaner. The temperature is thermostatically controlled, max. 40° C. The humidity is regulated by putting a piece of moistened cotton material between the perforated plates, below the picture. The moistened material can be removed anytime or remoistened several times. The heat makes the water evaporate, and the moisture will slowly be absorbed by the painting.

The painting is placed on cotton material, felt, a porous plate of polyethylene, or similar material in order to permit ventilation and prevent possible alteration of the surface structure.

Glue solutions for impregnation are sprayed directly on the backside of the painting.

Further Development of the Low-Pressure Apparatus.

Since 1978 the apparatus has been improved by Bent Hacke, also referred to in an article in these preprints. However, for reasons of economy and for the fact that we have not been quite satisfied with the heating sections used so far, we have simplified the apparatus in the following way. By removing the bottom of the low-pressure box and the heating section, and placing the remaining section directly on the hot table, the heat from the hot

table is utilized while the principle of the low-pressure apparatus remains unchanged, resulting in the same effect as the original.

Flattening.

By the flattening procedure all deformities are removed or diminished such as bulges, cupping, crackles with blistering paint, tears with irregular borders, or impastos with the paint pressed into the surface of the painting. By means of low-pressure, heat, and moisture these damages can slowly be repaired. Bulges can be straightened, cuppings smoothed out, crackles closed, and blistering paint straightened. With a view to the subsequent restoration it is possible to put canvas threads back where they belong. As to impastos the paint may probably have been pressed into the surface during a previous treatment, maybe because the painting has been ironed, or due to a too heavy pressure e.g. in a veneering press or on the hot table. But by treatment in the low-pressure apparatus the impasto may be re-established.

Having mentioned some of the possibilities for repairing damages, we should call attention to one specific case which may cause problems. If the original canvas is very coarsely woven, this may cause the weave to be imprinted into the paint layer, and in such cases it seems advisable to use a soft support or maybe to choose another procedure.

Whether to start with a moisture treatment or a glue impregnation depends on the character of the crackles, the blisterings, and on the flaking of the paint. It is preferable to start with a moisture treatment, but in case the paint is very loose, it is necessary to start with a glue impregnation. These processes are closely connected and may be executed alternately in order to obtain a good result without applying more moisture or more glue than necessary.

With its surface upwards the painting is mounted on a strainer by means of paper borders attached to the edges of the painting. When these borders have dried, they are covered with vinyl tape to prevent the passage of air and the reacting of the paper during the moisture treatment. The picture is placed in the low-pressure apparatus. The moisture treatment is started by application of moisture and heat. The best result is obtained by covering the painting with melinex while the moisture is penetrating, and not to establish the low-pressure before the reaction of the painting starts. The picture then becomes very flexible and may be easily flattened. The drying takes place without interruption, but by leaving the melinex on the painting the humidity can be maintained somewhat longer. The flattening takes place slowly and often over a long period. In our museum some pictures have been treated in the low-pressure apparatus for one hour only, while

others - in very bad condition - required treatment every day for a week. The painting is visible during the whole procedure so that it can be watched closely. As soon as the desired effect has been obtained the melinex is removed, and the picture is dried under pressure.

In our experience the most favourable result is obtained by gradually adding small amounts of moisture, as the desired surface will be maintained after the treatment, while a more rapid flattening by using larger amounts of moisture after a few days may produce the same damages as before the treatment.

While the damages are being treated, the moisture is activating the gelatine in the painting so that the canvas regains its former elasticity, and the paint layer is partly consolidated. After a moisture treatment many paintings will now be in a state that renders further treatment unnecessary.

However, part of the gelatine in the picture is often found to be so decomposed that a glue impregnation is required.

Impregnation.

By impregnation it is possible to fix loose ground layer and paint, to ensure the adhesion between the different layers of the painting, and to give the canvas some of its former elasticity. The impregnation is made by adding more glue which penetrates the painting during the treatment in the low-pressure apparatus.

In Russia where they have wide experience with fish glue, they recommend a 4-6% solution, applied by brush. In our museum considerably weaker concentrations are used, normally 1-2%. The glue impregnation is made over several times, partly to avoid too much humidity and partly to more exactly dose the glue. On damaged areas one can work partially with glue on the surface of the painting, while under pressure. (8)

After these treatments the paint layer should be consolidated, and some pictures should now be in perfect and lasting condition. Others have weak or damaged canvasses requiring support, and consequently it should be decided whether to make use of a striplining, a supporting canvas, a lamination, or a relining.

A Combination of Supporting Canvas and Striplining.

Striplining is very rarely used in our museum, a single piece of canvas is preferred, whether it is an unfixed supporting canvas or a lamination.

A combination of supporting canvas and striplining, which is most common, is made by pressing strips of a lamination folio lightly to the folded edges. The picture is placed on a piece of canvas, and the edges are sealed at 40° C either on the hot table or with a heating spatula. In

this way the backside of the picture is protected without using adhesives, and at the same time you get borders for another mounting on the stretcher.

Lamination Folio.

In our conservation department the lamination folio is made in the following way. A folio of polyester fibre is placed on a stretched piece of polyethylene folio and then impregnated with an acryl dispersion (4), applied by means of a paint roll or a brush. The impregnation is made two or three times, depending on how strong the adhesive between the original canvas and the supporting canvas should be. The acryl dispersion must dry for at least 24 hours between every single application. The lamination folio is used for lamination of paintings and for the above mentioned combination of supporting canvas and striplining as well. This lamination folio has the advantage of being dry. It is placed between the original canvas and the supporting canvas, and the adhesiveness is activated only at 35-40° C.

Regeneration in the Low-Pressure Apparatus of Paste Relinings.

Successful regenerations have been made of older paste relinings, of which the adhesive is partly decomposed, resulting in flaking paint. The picture being stretched with paper borders is treated in the low-pressure apparatus with heat and moisture, and is then remounted on its stretcher. If the original canvas or the relining canvas is coarsely woven, it is preferable to regenerate the paste relining with the surface of the painting turned downwards. In such cases the use of the hot table would be advisable.

Regeneration of Paste Relinings on the Hot Table.

The picture is stretched on a strainer so that it can be placed with its surface turned downwards on the hot table. The surface is placed on a suiting support covered by melinex. A piece of moistened machine-made paper is placed on the backside of the picture. This is covered and sealed with melinex. A low vacuum is established, max. 600 mm Hg, and the temperature not exceeding 35-40° C. In this way the moisture will penetrate the picture. After $\frac{1}{2}$ -1 hour the vacuum is interrupted, and the moistened paper is removed, and the vacuum re-established. After another half hour the melinex is opened to let possible moisture evaporate, and the vacuum is re-established. This ventilation is repeated until the picture appears to be dry. The treatment must be finished under vacuum, while the temperature is falling.

An Evaluation of Regenerations of Paste Relinings.

In many respects this treatment has been found satisfactory. The painting obtains a healthy surface, flattened

impasto is re-established, and the picture becomes more elastic. However, a regeneration can hardly be considered as durable as a new relining. But by a regeneration another relining - in itself a radical operation - may probably be postponed for some decades. This is advantageous, because a painting will always be weakened by the removal of paste. Thus, some years ago we removed some paste from a former relining and found fibres of canvas in 10% of the test piece. As a result we tried to remove relining paste with enzymes according to Frantisek Makes' instructions (5). The trials were convincing. The method, however, will require that a chemist be employed at the conservation department. So for the time being old paste will continue to be removed by hand or by moistening with rice starch.

Conclusion.

In our conservation department great interest is created by new experiments in connection with consolidation and relining, among these specially V.R. Mehra's experiments with "a low pressure cold-ling table" (6), and Robert Fieux' work with "Electrostatic Hold: A New Technique of Lining" (7), and Bent Hacke's development of the low-pressure apparatus (2), and we fully agree with their object. The reason why the low-pressure apparatus has been of special interest to us is that we stress the importance of the treatment of the picture preceding the lamination or relining of it, and to this end the low-pressure apparatus seems to offer the best possibilities.

Since the beginning of the sixties the preliminary work and the development of several precursors to the present apparatus have been followed in our department, and for the last four years we have worked with the latest model. More than 200 pictures have been treated by this means, every single one treated individually, but on the above lines.

The reason why we wish to draw attention to the potential of this method is that to-day considerable experience has been obtained. The results of the treatment are considerably better than previously. The original surface of the paintings being reproduced, while conserving the identity of the material, which is most satisfactory to us.

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Materials:

Acrylic emulsion: Plextol D 360, with a 5% thickener Rohagit SD 15. Röhm, Darmstadt. (4)

Melinex = Mylar = Hostaphan = Polyethylen terephthalate sheet. Hoechst or ICI. (3)

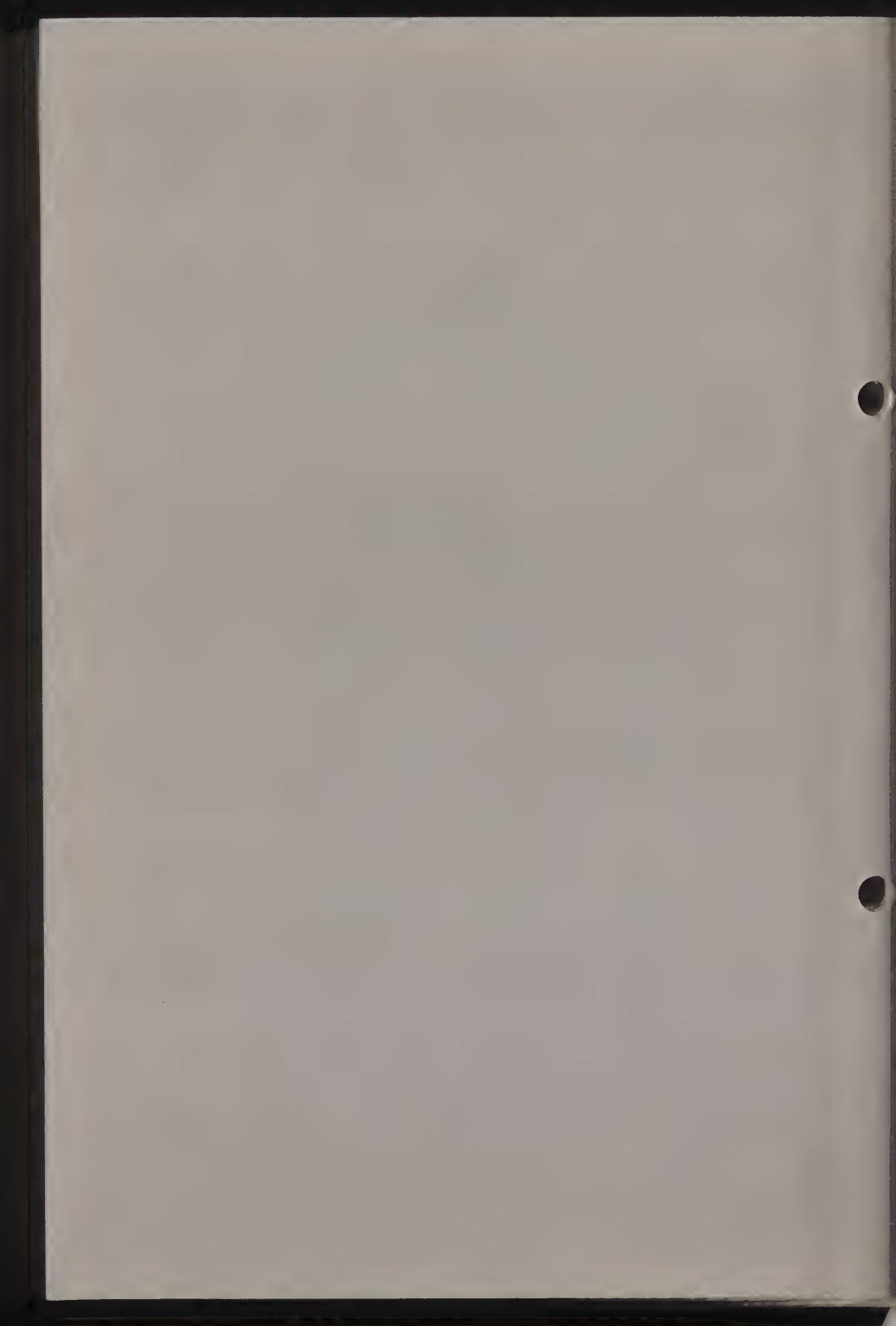
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PRINCIPLES AND TECHNIQUES OF SUCTION
LINING

Westby Percival-Prescott and Ronald
Chittenden

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Working Group: Structural Restoration of
of Canvas Paintings



PRINCIPLES AND TECHNIQUES OF SUCTION LINING

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Abstract

Lining becomes a necessary measure when a painting no longer has the physical means to support itself. But though a good lining must support the original painting, it should not reveal its presence by the alteration of the original surface topography or introduce unwanted structural features resulting solely from the lining treatment. We believe that the suction lining method offers a way to achieve these aims.

In 1974 the Conservation Department of the National Maritime Museum published a Paper giving details of the vacuum envelope lining system. The principles and the methods were fully explored and a film was also made to demonstrate the value of the method.

Full publication of this Paper was delayed as further modifications were gradually introduced into the technique. The modifications were all designed to make the method simpler in practice, more foolproof and more adapted to a wider range of problems. We recognised at this time that, although the vacuum envelope method was in many cases much better suited to meet the general problems posed by lining, the method still had some features which could be improved.

First, it is worth noting the main advantages that the vacuum envelope system introduces. These are:

1. The avoidance of a single source of pressure from the direction of the face or the reverse.
2. The value of being able to remove the painting during the lining operation for examination or withdrawal.
3. The value of using a heat source which can be separate from the painting during lining and the choice of a wide range of differing heat sources, e.g. scanning, infra-red heat, hot air blower, conventional hot table.
4. The opportunity of using two balanced sources of pressure reduced the risks of deformation to paint, the flattening of impastos and the pressing through of unwanted canvas textures caused by the unevenness of the structure of the lining canvas.
5. The value of the reduction of the period of heating from 30 to 40 minutes to 5 to 8 minutes to achieve the melting of the adhesive and the contact necessary for permanent adhesion.
6. This reduction in heating period reduces the risk of deformation of the original paint layers. The vehicular structure of the paint layers is less damaged by the much shorter heating period and fine scale surface heat scars which are often found on paintings lined in a conventional way with a hot table are completely eliminated.
7. Large paintings can be accommodated by this method, the hot table being used as a local heat source and the lining process can be carried out effectively in stages.
8. The original painting is, during the period of lining, held stretched from the four sides on to a loom. Thus it is lined in a tensioned condition similar to its original state. Its stretched form reduces the possibility of marked dimensional changes happening during the period of the lining, such as irregular shrinking.
9. The vacuum envelope method could be used with a wide range of adhesives and an adhesive could be specially selected to suit the problems encountered in the painting and the choice of the new lining support.

10. Lower vacuum pressures could be used using this system. Successful linings have been carried out with pressures as low as a half an inch of mercury. This compared very well with previous vacuum table methods which used 3" - 4" of mercury and with the earlier recommended pressures used of 7" - 10".

All of these advantages had been recognised over a period of years leading up to 1974 when we first gave public details of this lining method. However we did recognise at this time a number of limiting factors, such as the need for two separate looms during the lining and that linings carried out in this way, although possessing greater fidelity to the original surface structure, still had characteristics which were foreign to the painting's original appearance.

In an attempt to recognise and isolate the nature of these alterations we carried out a series of tests, both on simulated paintings and unimportant works. The results of these tests showed clearly that any form of restraint applied to the back of the original canvas would affect the surface topography of the original. For example, changes could be observed when even the thinnest layers of fabric were attached to the back of the painting. The presence of an adhesive layer alone was enough to cause minor surface deformation; this was sometimes greater than that caused by the application of heavier or denser inert materials.

All these experiments showed clearly that a painting on canvas is essentially a three-dimensional structure involving tension and stress observable in both lateral and cross sectional terms. These structural characteristics could, we found, be most clearly seen in paintings which had remained unlined, some ancient and some dating from recent years. By the use of raking light we gathered data determining the basic topography of a painting, face and reverse, and the factors which combined to create the main topographical features. It was noted for example that unlined paintings from the 18th century often displayed raised areas on the reverse of the painting corresponding to the positions of impastos and accumulations of raised paint on the face of the painting. It was clear that using a conventional lining method these raised areas on the reverse of the painting would be reduced or eliminated and the overall topography changed.

A series of tests was then carried out to determine the precise nature of the changes occurring on the reverse of paintings if raised impastos were added to a standard primed canvas and it was found that the lateral plane of the canvas could be altered within a relatively short period by the application of any irregular mass of paint to the face of the painting.

Obviously a number of factors were involved. Principal among these was the type of the paint used in terms of its initial contraction, plasticity and the period of time elapsing between the sequence of paintlayers. The volumetric change caused by delayed contraction which occurs in many types of paint and particularly in acrylic paints played a large part in producing a marked alteration to the face and the reverse. The stiffness, the tension and the type of canvas being employed as a support also contributed. One example is enough to show the importance of this phenomenon.

Using a thin cotton duck coated with a commercial white acrylic primer, a number of impasto strokes were applied irregularly to the surface of the primed canvas using an acrylic paint over a period of three days. Within two weeks these strokes could be clearly seen under raking light on the reverse of the canvas. They continued to increase in prominence and after a period of some months reached a state of equilibrium.

It was clear from this experiment that changes of plane affecting the reverse regularly happen during the period of the production of the painting and in many cases the artist would be working on surfaces which had or were being affected by rapid rheological changes. We recognised that earlier unlined paintings in oil on canvas showed similar raised patterns on the reverse. These factors led us to search for a method of lining which would more closely reproduce the original irregular planal topography of the reverse. The outcome of this search was the suction lining method.

Whilst vacuum envelope lining depends on a limited and balanced pressure being applied from the face and the reverse simultaneously, suction lining is based on a pressure being made by the partial extraction of the air from between the lining canvas and the original painting. Its aim is to bring the new support coated with an inert thermoplastic adhesive into contact with the reverse side

of the painting without causing unwanted alteration to the irregular surface topography formed on both sides of the painting. It is if possible carried out without a facing paper attached to the face. The painting is held at the edges with paper and stretched to a loom. Suction lining is a rational development of the vacuum envelope method with the important modification that the plastic membrane normally used over the face of the original painting has in this case been omitted and the painting itself acts as an integral component of the suction system.

The requirements for this new method differ slightly from those for the vacuum envelope system. The gradual withdrawal of air during lining and the sequence of the withdrawal allowing clear exit routes for evacuation initially gave us some difficulties but these problems have been largely overcome and over the past five years we have lined many pictures very successfully using this method. (The details of the method are to be found in the Appendix). We now believe we have gained sufficient experience to recommend it to other conservators, as a method which has a number of substantial advantages over the vacuum envelope technique.

The additional advantages are as follows:

1. The lining can be carried out without a facing paper or any direct external pressure from the face and is therefore suited to the treatment of modern paintings having high or delicate impastos, as well as the more traditional types of easel painting.
2. The system offers a safe way of attaching a new support to the painting which closely follows the original topography of the reverse of the canvas and thus avoids the types distortion sometimes introduced by the traditional flattening agents, e.g. iron, hot table or veneer press.
3. The duration of heating of the painting has once again been reduced using a mobile heat source, e.g. hot air blower, the period of the local heating of any area of the painting can be reduced to less than 30 secs. If the hot table is used as an overall heat source, a method we use on most occasions, the period of heating is similar to the previous vacuum envelope system, the duration being determined by the nature of the adhesive used and its varying thermoplastic characteristics.

Few conservators wish to ignore the special qualities that can be observed in a painting which has remained unlined, the vitality of touch, the differences of texture and the subtle qualities of canvas tension. The suction lining method aims at retaining these qualities and regularly succeeds in doing so.

Acknowledgments

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We should like to thank, in particular, Miss Elizabeth Hamilton-Eddy for her valuable contribution.

Stages of Suction Lining

1. Should the painting require the removal of varnish as well as lining treatment, this should take place first.
2. A single or a double facing of Eltoline tissue should be applied to the face of the painting using Beva 371 thinned in suitable solvents. The number of facing tissues used depends on the condition of the painting. Following the drying of the facings, the painting can be removed from its stretcher, turned over and the reverse cleaned.
3. A sheet of litho paper (undersized cartridge, light weight grade) cut from the roll to a size 6 - 10" larger than the painting. This allows a margin of 3 - 5". The width of the margin depends on the size of the painting being lined. The paper should be in one continuous sheet.
4. The litho paper should be sponged with water and allowed to swell fully. All unevenness must be smoothed out from the paper surface using a wet sponge (Spontex).
5. An area corresponding to the size of the painting in the middle of this sheet is then brushed evenly with starch paste or suitable aqueous adhesive, and the facing paper applied to the surface of the painting over the Eltoline tissue facings. All air bubbles trapped between the painting and the litho facing must be removed by rolling lightly from the centre with a soft rubber roller.
6. The edges of the litho paper facing are now attached to a rigid support. We use for this purpose a hardboard laminated with an expanded polystyrene core. The edges are attached to the supporting board using gummed paper tape, and the painting with its facing is allowed to dry and gradually pull itself taut.
7. When the faced painting is completely dry the litho paper can be cut free along the outer edge and the whole painting is then carefully turned face down. The paper edges are dampened and re-attached to the board support using gummed paper.

8. This is the stage for the removal of the old lining fabric should any exist and the remains of lining adhesive. Treatment for the reduction of planal distort or cupping should now also take place if necessary. The painting may be restretched as often as required by trimming the litho paper facing to within $\frac{3}{4}$ " of the painting's edge and attaching fresh strips of dampened litho paper or strips of heavier rag cartridge paper which creates a stronger pulling edge if such is required.
9. If the painting requires consolidation, it should take place at this stage using a suitable consolidant. The painting may be treated from the face or the reverse if necessary, all of the facing papers renewed.
10. If the canvas has become very weakened or friable, a thin layer of Beva 371 can be applied as an overall consolidant but should the canvas be strong enough no adhesive need be applied to the back of the painting, allowing a nap bond type of lining to be used which is always the best method.
11. Lining may be carried out with or without a facing depending on the condition of the painting. Should the painting require the retention of the facing paper, this can be cut free leaving the wide paper margins at the edges, and the painting is laid face down upon a suitable sized loom (A) to which it is taped. To enable the painting to be supported in this position a removable wooden panel is placed within the loom below the painting.
12. It should be noted that the use of a facing during lining increases the risk of deformation. For this reason one always aims at carrying out suction lining without an overall facing paper if the condition of the picture allows it. The facings are now removed from the upper surface of the painting to within half an inch of the inner edge of the picture and the edges of the paper are feathered to avoid marking the painting's surface during the lining process.
13. The lining fabric we most commonly use is heat treated glass fibre or Tencate. This should be stretched upon loom (b) which is at least 2" larger (overall) than the picture loom (A) and an area the exact size of the painting is then coated with a suitable lining adhesive. Beva 371 has been found to be useful.

14. The lining fabric upon its loom (B) is then placed over the painting loom (A) and aligned to have the area of the adhesive corresponding with the area of the painting. The lining canvas is then stapled to the loom (A) and the edges are cut free. This allows the larger loom (B) to be completely removed.
15. Fine regular polyester net is then stretched over the back of the lining fabric to act as a breather. This is stapled onto the edges of loom (A).
16. A layer of thin PVC sheeting acting as a membrane is gently stretched and stuck to the edges of loom (A) using double sided sticky tape. This layer completes the "envelope" and provides the air seal.
17. Successful results can generally be achieved using this suction lining method which differs from the vacuum envelope method only in that the PVC membrane normally in contact with the face of the painting is omitted. In its place a separate piece of fine gauge melinex is laid loosely over the upper surface allowing the painting itself to become an integral part of the vacuum envelope. During the process the painting is sucked gently into contact with the lining fabric during the period of the lining process.
18. A 3" square of double sided sticky sheet (Lomacol) is placed in the centre of the paper margins on each side of the loom. An opening of about 1" in diameter is cut through this sticky film and also through the paper, revealing the lining fabric which is not cut. Over these openings wide suction cups are placed with tubes which carry the evacuated air to the pump. A vacuum pressure of $\frac{1}{4}$ " to $\frac{1}{2}$ " of mercury is sufficient to obtain suitable contact. As this system involves the use of only partial vacuum and depends on the limited passage of air through the face of the painting higher levels of vacuum pressure may be registered on the gauge. The vacuum levels we recommend of about $\frac{1}{2}$ " of mercury are obtained locally and must be estimated in situ. 2 or 4 air lines are necessary to provide adequate movement of the painting from the serving table to the hot table.
19. The hot table is pre-heated to approx. 60°C and the painting in its envelope (which is already under vacuum)

is placed upon it. Thermostrips are attached to the paper edges and observed during the short heating period. The temperature is raised to 70°C and the painting is held at this temperature for a period of five minutes. During this period the painting is maintained under vacuum and can, if necessary, be removed from the hot table for examination or localized treatment.

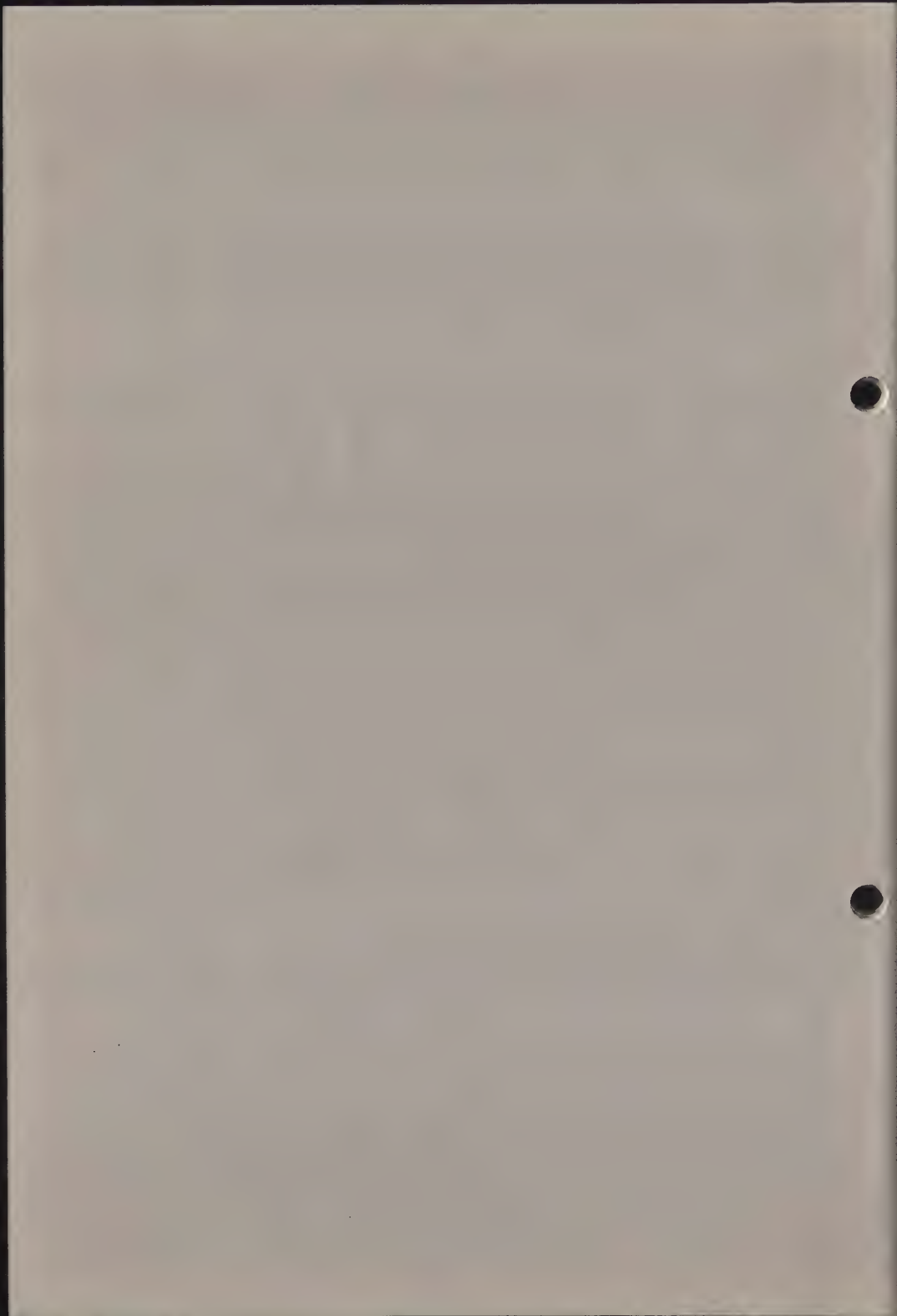
20. When the period of heating is complete the painting (still under vacuum) is removed from the hot table to a nearby serving table and allowed to cool. The cooling process is a rapid one, and on its completion the vacuum pump is switched off. The painting can then be left on its loom for a period of about 24 hours after which it is cut free from the loom and stretched onto a suitable wooden stretcher using stainless steel staples in place of tacks. These staples should be driven through a strip of thick cloth tape which serves to protect the original tacking edges and the lining fabric.

TROIS CAS DE RENTOILAGE TRANSPARENT FAITS
PAR G. TEN KATE AU SERVICE DE LA RESTAURATION
DES PEINTURES DES MUSEES NATIONAUX

E. Pacoud-Reme

Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981

Groupe de travail: Restauration structurale
des peintures sur toile



TROIS CAS DE RENTOILAGE TRANSPARENT FAITS PAR G. TEN KATE
AU SERVICE DE LA RESTAURATION DES PEINTURES DES MUSEES
NATIONAUX

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Résumé : Trois tableaux qui avaient été anciennement rentoilés, présentaient lors de l'intervention du S.R.P.M.N. des soulèvements généralisés et des accidents graves. Ils devaient être rentoilés à la colle de pâte. Lors de l'enlèvement de l'ancienne toile de rentoilage sont apparus au revers des toiles originales des éléments peints très importants pour l'histoire du tableau (inscriptions permettant dans un cas l'identification du personnage et la date de l'oeuvre, dans un autre l'attribution du tableau). Les opérations du rentoilage à la colle ont donc été modifiées afin de rendre possible un rentoilage transparent pour lequel ont été testés un adhésif (à base de cire-résine) et un textile (tissage de fibres de verre). Enfin un type de châssis transparent a été mis au point.

-:-:-:-

Trois tableaux ont fait récemment l'objet de rentoilages transparents lors de leur restauration au S.R.P.M.N.

Il s'agit d'un Portrait d'Homme de J. de BRAY, appartenant au Musée Jacquemart André (Institut de France, Paris) rentoilé en 1976, d'une Andromède, appartenant au Musée National Magnin de Dijon, rentoilé en 1977, enfin de la Guerre des Amours, de J. de Hoey, appartenant au Musée de l'Assistance Publique, de Paris, rentoilé en 1980.

Ces trois tableaux avaient été anciennement rentoilés. Mais au moment de l'intervention du S.R.P.M.N., ils étaient en soulèvements généralisés et nécessitaient une reprise de rentoilage. Le Portrait d'Homme présentait en outre des déformations dans le visage de l'homme, dues à d'anciennes déchirures (qui avaient exigé le précédent rentoilage). Sur La Guerre des Amours, d'importantes coulures d'eau avaient affecté tout le quart inférieur gauche du tableau, entraînant de graves déformations de la toile. La reprise de rentoilage avait donc été envisagée à la colle de pâte (1), pour obtenir une reprise satisfaisante des déformations et une bonne tenue des lèvres des déchirures.

Dans les trois cas, c'est lors de l'enlèvement de l'ancienne toile de rentoilage que sont apparus, au revers de la toile originale, des éléments peints très importants pour la connaissance de ces oeuvres. Plutôt que de se contenter de documenter cette peinture au revers, avant de la recouvrir de nouveau, on a préféré chercher un moyen de la laisser visible. Il a donc fallu modifier certaines opérations du rentoilage à la colle prévue initialement et terminer à la cire-résine pour la pose du support de renfort en toile de fibres de verre (2).

Enfin un châssis transparent a été mis au point afin de permettre la lisibilité complète du revers.

(1) Colle de pâte : colle de farine, de seigle ou de froment (à base d'amidon), avec addition de colle d'os ou de nerf (protéinique) et divers adjuvants (plastifiants tels la térébenthine de Venise, émollient tel que l'extract de graine de lin, désinfectants soit phénolés soit sous forme de sels métalliques).

Rappelons brièvement les différentes étapes du rentoilage à la colle de pâte : après mise à tirants, et cartonnage à la colle de pâte ; le tableau est retourné, l'ancienne toile de rentoilage enlevée et l'ancienne colle grattée, si le tableau avait été rentoilé auparavant. Puis, pour rétablir l'adhérence de la couche picturale au support, intervient le refixage général par le revers à la colle de peau chaude. Enfin on pose, à la colle de pâte, une ou deux gazes (selon la faiblesse du textile original) puis la toile de rentoilage, en toile de lin décatie, débarassée à l'eau chaude des produits d'encollage nécessaire à la filature et au tissage. Le tableau est de nouveau retourné, le cartonnage enlevé et remplacé par un papier calque ou sulfurisé, puis repassé à travers un molleton, s'il faut protéger les empâtements. La toile de rentoilage est enfin coupée et le tableau retendu sur son châssis.

(2) Un exemple de rentoilage transparent avec une toile de fibres de verre a été montré en 1972 à l'exposition "Firenze Restaura" à Florence (Catalogue, P.83 et 135).

I - La découverte du revers de la toile originale et la décision de rentoilage transparent :

Les tableaux ont donc été mis à tirants. (bandes de papier collées sur tout le périmètre à demi sur le tableau, à demi sur la table de rentoilage) cartonnés avec plusieurs feuilles de papier juxtaposées, et retournés pour l'enlèvement de l'ancienne toile de rentoilage. Les éléments suivants sont alors apparus au revers des toiles originales :

Portrait d'Homme : à la partie supérieure de la toile : quatre écussons portant des armoiries, et une inscription : D. Heer en Mr- Nicolaes de Bÿe- Raadsheer in den- Hoogen Raad- Geb : den 29 guni- 1610 gest den febernari- 1675.

Andromède : une esquisse de personnage en buste assis devant une table, à l'ocre rouge, occupant toute la surface de la toile.

La Guerre des Amours : un numéro et une inscription : 259. Jean de Hooy, (illisible), peintre du Roy de France.

Les conservateurs responsables de ces oeuvres ont confirmé l'importance de ces découvertes, qui ont permis l'identification du personnage peint par J. de DRAY (N. de Bÿe né le 29 Juin 1610, mort en Février 1675), et l'attribution de La Guerre des Amours à J. de HOEY (célèbre peintre de la seconde École de Fontainebleau auquel on attribue des travaux importants au Louvre dans la "Petite Galerie").

Les responsables du S.R.P.M.N. proposèrent donc un rentoilage transparent dont les différentes opérations furent mises au point par G. TEN KATE.

Il fallait trouver un adhésif et un textile d'indices de réfraction proches, afin d'obtenir un milieu homogène, donc une bonne transmission de la lumière. Le choix s'est donc porté sur la cire-résine pour l'adhésif, et la fibre de verre pour le matériau du support de renfort.

Plusieurs essais ont été effectués avant de déterminer l'ensemble qui assurerait le résultat le plus transparent. L'adhésif choisi est un mélange de cire d'abeille, incolore, de résine dammar, et de térébenthine de Venise. Ce mélange est filtré et éclairci au charbon actif en petite quantité.

Pour le textile, différents types de fibres de verre, tissées ou non, ont été testés. Le tissage a été retenu car il est plus résistant et plus transparent une fois imprégné de l'adhésif.

II - Le rentoilage transparent :

Une fois enlevée l'ancienne toile de rentoilage, le nettoyage de l'ancienne colle a été mené avec des précautions particulières afin de ne pas user les motifs ou inscriptions découverts au revers.

Pour les trois tableaux, le rentoilleur a alors procédé au refixage par imprégnation générale du revers à la colle de peau chaude.

Les opérations se diversifient ensuite selon les tableaux :

* Andromède, le cas le plus simple, a été retourné, et le cartonnage a été remplacé par une seule feuille de papier calque, afin d'éviter que les joints ne marquent lors des dernières étapes du rentoilage.

* Le Portrait d'Homme a reçu une gaze provisoire posée à la colle de pâte légère, puis fut retournée sur son fond, et décartonnée, afin qu'on puisse procéder à l'allègement du vernis très épais et à l'enlèvement des repeints et des mastics anciens, boursoufflés, qui risquaient de gêner la suite du rentoilage. Une fois le nettoyage achevé, la face du tableau a été couverte également d'une seule feuille de papier calque, le tableau retourné de nouveau, et la gaze provisoire enlevée. Elle a permis une meilleure reprise des boursoufflures dues aux déchirures anciennes.

* Pour La Guerre des Amours, le rentoilage à la colle a été terminé (pose d'une gaze et de la toile de rentoilage) retourné, décartonné, et nettoyé également (allègement du vernis et enlèvement des repeints et mastics anciens). Après le nettoyage, la face du tableau a été couverte d'une seule feuille de papier calque. On a pu alors, grâce à l'achèvement du rentoilage, procéder au repassage sur la face, qui pouvait, dans la méthode à la colle permettre de retrouver aisément un bon état de surface. Le tableau a ensuite été retourné et dérentoilé (enlèvement de la toile neuve et de la gaze).

Puis dans les trois cas, sur le périmètre du revers de la toile originale, ont été posées à la colle de pâte, des bandes de tension en toile de lin, à un cm des bords environ. Le côté de la bande collé au tableau est effranger sur un demi cm environ pour que la limite de la bande ne marque pas sur la face avec le temps.

Ces bandes sont suffisamment solides pour résister à la tension modérée sur châssis ; le périmètre de la toile de fibres de verre, matériau assez mou, sujet à fluage, ne peut en effet jouer un rôle.

L'ensemble du revers a ensuite été enduit du mélange cire-résine décrit ci-dessus. La toile de fibres de verre pré-découpée au format du tableau a ensuite été étendue sur le revers.

III- Les Chassis :

Le tableau représentant Andromède a provisoirement été remonté sur un châssis en bois traditionnel.

Pour les deux autres tableaux ont été mis au point des châssis transparents. Leurs dimensions étaient telles qu'ils devaient comporter des traverses en croix. La croix a été découpée d'un seul tenant dans une plaque de méthacrylate de méthyle (3).

Le revers du tableau de J. de BRAY étant peint presque jusqu'au bord supérieur de la toile, le châssis a été entièrement conçu en méthacrylate de méthyle. Les assemblages sont assurés par des tenons passants. Une vis réglable, aux extrémités de la croix et aux angles du châssis, permet une tension variable. Pour pouvoir clouer la toile sur le châssis, une mince bande de bois périmétrique a été collée avec une colle acrylique.

Le revers du tableau de J. de MOEY ne comportant qu'une inscription centrale, seule la croix a été prévue transparente. Les montants périmétriques du châssis sont en sipo, bois de très faible variabilité dimensionnelle. L'assemblage entre le bois et le méthacrylate de méthyle se fait également par tenons mais les variations de tension sont cette fois rendues possibles par le système traditionnel de clefs aux angles.

Chaque tableau a donc reçu un traitement différent destiné à remédier à ses altérations spécifiques: Andromède, le cas le plus simple, a été commencé à la colle jusqu'au refixage, et terminé à la cire-résine. Pour Le Portrait d'Homme, la pose d'une gaze provisoire après le refixage a rendu les opérations déjà plus complexes. L'innovation réside dans la mise au point du châssis transparent. Enfin, La Guerre des Amours, a reçu successivement un rentoilage à la colle puis un rentoilage partiel à la cire-résine.

Dans tous les cas, ces interventions ont permis de retrouver un état de surface satisfaisant, une bonne adhérence de la couche picturale à son support, tout en laissant visible le revers, dont les éléments, de la plus grande importance pour l'histoire du tableau, et si longtemps ignorés, sont désormais facilement accessibles.

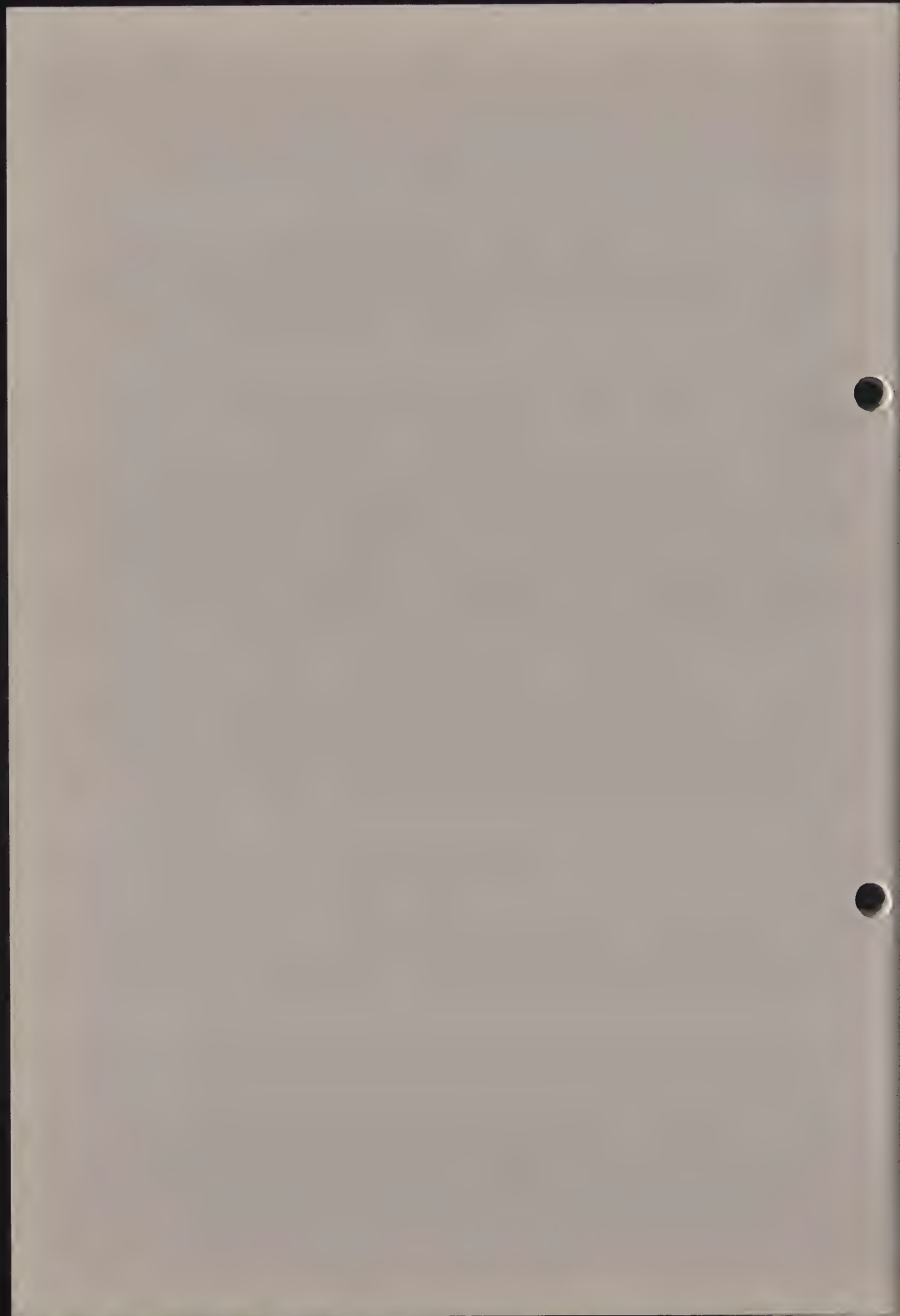
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A STUDY OF MATERIALS FOR FILLING LOSSES
IN EASEL PAINTINGS, AND THEIR
RECEPTIVENESS TO CASTING OF TEXTURES

Jan Green and Joan Seddon

ICOM Committee for Conservation
6th Triennial Meeting
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AND THEIR RECEPTIVENESS TO CASTING OF TEXTURES

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ABSTRACT

Isolated samples of commonly used or potentially useful fillers were tested to establish the tensile break strength, shrinkage, adhesion, stiffness, handling and convenience. Results showed a very wide range of strength, stiffness and shrinkage.

Further tests were designed to identify the most suitable combination of filler and moulding material, for the purpose of casting surface textures.

INTRODUCTION

The materials used for filling losses in easel paintings have been little studied, and the subject is complicated by many variable factors. Slight variations in the source and quality of ingredients, the method of application, and fluctuation in environmental conditions, can produce very different results. Most recipes are vague about proportions of mixtures, while the 'ideal' texture and consistency of a filler is a highly subjective judgement. Requirements for a filler may vary according to the nature of the support, paint film and damage, as well as the lining, varnishing and retouching system preferred by the restorer.

It is assumed here that the chief purpose of a filling material is to effect a convincing repair, fully integrated with the paint surface, and that good filling is a prerequisite for good retouching. Traditionally, fillers have been composed of an inert white solid, such as whiting, combined with an aqueous adhesive such as gelatine. Additives such as wax, drying oils, resins, egg yolk and honey, have commonly been added as plasticisers or to improve the handling properties. These materials may have certain disadvantages, such as

brittleness, but are relatively simple and predictable. In recent years various synthetic and commercially prepared materials have become available, many of them specifically designed for filling, modelling and imitating impasto textures. The exact composition of these materials is usually unknown, and they have not been tested by conservators.

This paper is a preliminary survey of the range of filling materials, guided by the following criteria:

1. filling must have good adhesion.

It should have good working properties. It should be simple to prepare; if complicated, it should remain usable for some time, particularly if losses to be filled are large or numerous. It should have a suitable drying rate, neither too slow nor too fast.

It should have strength and flexibility. If a filling is much more brittle than the support, it will not accommodate itself to slight movements. Ideally it should have some plasticity and the ability to take a surface texture; this is dealt with in the second part of this paper.

It should have high stability under varying conditions of temperature and humidity. It must not crack or develop mould. It should have minimum shrinkage. This is especially important when texturing fillings, since dramatic shrinkage on drying will cause the loss of a cast texture.

It should be reversible but not too readily soluble; the restorer may wish to remove the varnish and retouching layer without disturbing good fillings.

The porosity of the filler should match that of the surrounding area; otherwise it may absorb varnish and retouchings differently from the original, becoming too matt or shiny. (This may be adjusted by applying an isolatin layer before varnishing.)

TESTING PROCEDURE

(All samples were prepared in conditions of 14°C ($+/-2^{\circ}$) and 50% R.H.)

No attempt was made to simulate the conditions of filling losses in paintings. Isolated strips of each material were obtained by applying the filler through a stencil of known thickness to a sheet of Melinex; the surface was levelled and the stencil removed. Where appropriate, a record was made of the ratio of solid and binder, by volume. General observations were made about the handling, appearance and behaviour of each filler before, during and after application. When dry, samples were removed from the Melinex, noting the adhesion. The thickness of each sample was then measured with a micrometer, and recorded as a percentage of the original thickness. To allow for variations within the sample, three or four measurements were taken at different points and an average result obtained. Two samples of each material were prepared, originally 0.75 and 1.15 mm. thick.

The samples were tested on an Instron tensile testing machine (model 1026) which recorded the tensile break load. A few samples could not be tested; either they could not be removed from the Melinex, or they had cracked severely on drying, or the sample could not be placed in the grip of the machine without breaking because of the severe planal distortion which had occurred during drying. The degree of extension of a sample before it failed was taken as an indication of its stiffness.

RESULTS

Table 1 shows the recorded results and comments.

Other observations can be made about the materials and the limitations of the testing procedure:

Shrinkage: All the materials tested dry by evaporation of a solvent and therefore shrank to some extent. The higher the proportion of solid, the less a sample shrank; however, the solid content could only be increased up to a certain point, beyond which the filler became underbound and crumbly.

Some samples appeared to have increased in thickness instead of shrinking. Those which had poor adhesion to the Melinex (marked *) seemed to have retracted towards the centre of the sample; a more accurate measurement would have been obtained by recording the reduction in surface area rather than in thickness. Other samples which seemed to have swelled may have reacted to moisture, while some error in the preparation of the sample cannot be discounted.

Tensile break strength: It should be noted when interpreting the table of results that the samples tested, having dried and shrunk, were of different thicknesses.

Adhesion: All the samples except for the very fluid materials curled up slightly at the edges. This may have been due to surface retraction on drying, or because the removal of the stencil tended to lift the edges of the sample.

If the adhesion of the filler to Melinex was greater than its cohesion, it tended to remain attached to the Melinex but cracked on drying. If the filler had poor adhesion to Melinex but good cohesion, it was less likely to crack but tended to detach itself from the Melinex. Some very fluid and plastic materials remained firmly attached, without cracking, despite having the greatest shrinkage. Any sample which both cracked and fell off the Melinex was probably underbound or contained a weak adhesive.

The poor adhesion of a filler to Melinex should not be taken to indicate that it could not be used successfully on a painting.

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MATERIAL	COMPOSITION	TENSILE BREAK STRENGTH (Kg.)	% ORIGINAL THICKNESS	
			(i)	(ii)
Minsor & Newton Aquapasto	gum arabic + silica	2.0-3.0	54.7	48.7
Aquapasto	+ whiting 1:3	-	90.7	93.9
Aquapasto	+ CaCO ₃ 1:4	2.5	93.3	104.3
Minsor & Newton Oleopasto	oil modified alkyd resin + silica	-	68.0	62.6
Oleopasto	+ CaCO ₃ 1:4	1.5	90.7	93.0
Oleopasto	+ whiting 1:3	1.5	74.7	79.1
Sealobond	PVA emulsion + whiting 1:2	14.0-22.0	60.0	60.9
Mowilith DM5	PVA emulsion + whiting 1:2	6.0-8.0	70.7	79.1
Rowney Cryla Primer	Acrylic emulsion	2.5	33.3	31.3
Cryla Primer	+ CaCO ₃ 1:3	3.0	84.0	81.7
Cryla Primer	+ CaSO ₄ 1:4	1.5-2.0	78.7	93.0
Rowney Cryla Texture Paste	Acrylic emulsion	2.5	53.3	60.9
Cryla Texture Paste	+ whiting 1:2	1.5-2.5	86.7	93.0
Cryla Texture Paste	+ CaCO ₃ 1:2	-	89.3	100.9
Liquitex	Acrylic emulsion			
Modeling paste	+ marble dust	-	90.7	93.9
Liquitex gesso	Acrylic emulsion	2.5-3.0	53.3	51.3
Liquitex gesso	+ whiting 1:1	5.0	64.0	74.8
Instant	PVA emulsion			
Polyfilla	+ chalk	7.0-9.0	74.7	86.1
Fine Surface	PVA emulsion			
Polyfilla	+ chalk	4.0	81.3	80.9
Beva 371	+ whiting 1:3	0.5	81.3	86.1
Paraloid B72	+ whiting 1:3	7.5	78.7	72.2
National Mari- time Museum putty	Polyurethane varnish; beeswax; BaSO ₄ ; whiting	2.5-3.0	101.3	88.7
Brunner	oil/size/chalk	-	138.0	117.4
Cellofas 'B'	+ whiting 1:4	0.5	89.3	96.5
Gelatine	+ CaCO ₃ 1:4	1.0	148.0	124.3
Gelatine	+ whiting + stand oil	0.25	102.7	102.6
Ruhemann's putty	whiting/stand oil/ beeswax	1.5	93.3	102.6
Rabbit skin glue	+ whiting 1:4	-	86.7	105.2
Rabbit skin glue	+ whiting 1:4 + mastic	negligible result	96.0	105.2

Table 1

CaCO₃ = precipitated chalk

ADHESION CRACKING STIFFNESS HANDLING CONVENIENCE/COMMENTS

1:stiffest

3:least stiff

Good	-	3	Good	From tube. Very soft.
Good	slight	2	Good	Easy to mix.
Good	-	2	Good	Easy to mix.
Good	-	3	Poor	From tube. Sticky, slow drying.
Good	-	2	Fair	Easy to mix.
Good	slight	2	Fair	Easy to mix.
Good	-	1	Poor	Very fluid and sticky.
Good	-	2	Poor	Hard to mix. Very fast drying.
Good	-	3	Fair	From tin. Slow drying.
Good	-	2	Good	Easy to mix.
Good	-	2	Good	Easy to mix.
Good	-	3	Good	From jar. Slow drying.
Good	severe	2	Good	Easy to mix.
Good	-	2	Good	Easy to mix.
Good	severe	-	Good	From jar. Fast drying.
Good	-	3	Fair	From jar.
Poor	severe	2	Fair	Very little cohesion.
Good	-	1	Good	From tube.
Good	slight	1	Good	From jar.
Good	slight	1	Poor	Hard to mix. V.sticky.
Fair	-	1	Poor	Very fast drying.
Good	-	2	Good	Difficult to make large quantity
Poor	severe	1	Poor	From tin.V.brittle.*
Poor	-	1	Fair	Easy to mix. Fragile*
Poor	severe	1	Good	Easy to mix*
Poor	-	1	Good	Easy to mix*
Fair	-	1	Good	Complicated.
Poor	severe	1	Good	Easy to mix.Fragile*
Poor	-	1	Good	Easy to mix*

Table 1

CONCLUSIONS

1. Severe shrinkage of a filler, eg. to less than 80% of its original thickness, may be considered a major disadvantage. Certain materials, particularly the commercially produced brands which are already carefully formulated for an optimum ratio of binder and solid, will not readily take an increase in solid content without losing adhesion. Shrinkage may be reduced, however, by allowing the filler to dry partially before applying it to the loss. In practice it is likely that filling will be carried out in several stages, repeating the application where necessary.
2. Fillers which have moderate strength and high elasticity are potentially more useful than extremely strong fillers. It is undesirable that the filler should be more rigid than the paint film to which it is applied.
3. The inclusion of additives in a home-made filler introduces a number of variable factors, without necessarily improving the overall properties of the filler. This may be balanced or outweighed by the benefits of using a filler of known composition.
4. Ordinary gilder's whiting, which has particles of varied and irregular shape and size, is of more general use in mixtures than precipitated chalk, CaCO_3 . The latter has more regularly shaped particles which seem to pack together, reducing the absorption of adhesive with resulting loss of 'tack'.
5. It remains to carry out ageing and solubility tests on the samples.

ACKNOWLEDGEMENTS

The research from which this paper is taken was carried out as a Diploma project for the Courtauld Institute Technology Department and the National Maritime Museum Conservation Department in 1979.

I would like to thank the staff of the National Maritime Museum Conservation Studio, the Tate Gallery Conservation Studio and the Courtauld Institute Technology Department for their assistance with this project.

CASTING OF SURFACE TEXTUREINTRODUCTION

Good retouching over a damage can often depend on the success of the underlying filling in imitating the conformation of the original layers. Restorers are aware that an incorrectly textured filling which scatters light at variance with the original paint surface is difficult to disguise. The casting of surface texture, using a mould taken from the original painting, may offer a solution which is simple, quick, safe, and at the same time, aesthetically pleasing.

Many excellent filling materials now exist; equally there are a number of potentially useful casting materials. Difficulty arises in combining the two, as very few give good and consistently reliable results when used in conjunction with one another. This difficulty may be reduced by observing the following:

1) The drying rate of the filler should not be too critical, and should be easily established. It must be possible to judge the moment when the filling is still soft enough to receive an impression; at the same time it must have sufficient cohesion and adhesion not to be displaced by the action of applying a mould. It is a common failing of casting that the removal of the mould, at whatever stage of the process, and despite using a release agent, drags the surface and spoils the impression. As yet there is no guaranteed method of avoiding this.

2) The material used for taking an impression should be highly flexible. While taking the impression, it is most undesirable to subject the painting to undue strain; a thin, flexible film which can be gently peeled back from the surface is preferable to a rigid cast which must be lifted off at a 90° angle. The casting of a paint surface is not analogous to making a seal impression.

3) The casting material should not undergo dimensional changes while setting, since this will not only produce an inaccurate impression but may drag and damage the paint surface from which it is taken. Ideally, it should have a rapid setting action.

TESTING PROCEDURE

Tests were designed which roughly simulated the filling of damages. Strips of canvas, 10 cms X 25.5 cms and 0.50 mm. thick, were prepared. Identical shaped and sized holes, approximately 4.5 X 3.5 cms., were cut in the centre of each strip, which was then lined with wax-resin adhesive on to a strip of raw, washed canvas, thus producing a simulated loss of 0.20 mm. depth. The general characteristics of most of

the fillers tested have been described in this paper. The fillers were applied with a spatula and the surface levelled.

Casts were taken from two different canvases using four casting materials and applied to the fillings. After 24 hours, each sample was assessed in terms of the success of the cast impression. To establish whether the material conformed to other filling requirements, each canvas strip was bent round a fixed curve (a glass cylinder, circumference 25.5 cms). Deformation or cracking of the filling was observed, as an indication of elasticity and adhesion.

While making casts, the following essential precautions were taken:

1. The canvas was firmly supported by a hard surface while taking and applying an impression.
2. A release agent (talc) was used with the casting material.
3. The prepared cast was applied to the filling and weighted with a glass plate to ensure good contact while setting took place.
4. Application and removal of the cast was carefully timed. The point at which a cast could be applied and removed was critical, but was determined by trial and error. This critical point was specific for each filling material.
5. A register mark was made on the reverse of the cast to ensure that it could be correctly aligned when applied to the filling.

RESULTS

Filling materials Three materials did not prove receptive to any form of casting attempted. These were Brummer, Polyfilla and Liquitex Modelling paste.

Two materials produced excellent cast impressions but demonstrated high shrinkage, poor strength and poor elasticity. These were a whiting, gelatine and stand oil putty, and Cellofas B plus whiting.

Five materials produced good cast impressions and appeared to have minimum shrinkage, with good adhesion and flexibility; these were: Fine surface Polyfilla; Winsor and Newton Aquapasto + whiting; Winsor and Newton Oleopasto + whiting; The National Maritime Museum (Greenwich) putty; Plextol B 500 + whiting.

Casting materials

Reposil Light Addition cured silicone
Manufacturers: De Trey AG, Zurich.

Working time: 4 minutes

Setting time: $3\frac{1}{2}$ minutes

Shrinkage: estimated by manufacturers at 0.15% after 24 hours.

A highly flexible film which could be used without a release agent and was particularly good for casting fine textures.

(Illustrated, Photograph 1)

Reposil putty Addition cured silicone
Manufacturers: De Trey AG, Zurich.

Working time: $2\frac{1}{2}$ minutes

Setting time: $2\frac{1}{2}$ minutes

Shrinkage: estimated by manufacturers at 0.01% after 24 hours.

A thicker and more solid cast than Reposil Light, but quite easy to handle and good for most surfaces.

Silastic 504 Cold cure silicone rubber
Manufacturers: Dow Corning International Ltd.

Working time: 5 minutes to 8 hours, depending on catalyst.

Setting time: 15 minutes to 48 hours, depending on catalyst.

Manufacturers recommend that optimum properties are obtained after 72 hours.

Shrinkage: estimated by manufacturers at 0.3% after 7 days.

This tended to be difficult to make up, and slow setting.

When made it produced quite a good cast, and remained an elastic material.

Vinagel 116 Heat-cured PVC
Manufacturers: Vinatex Ltd. Special products
Division, New Lane, Havant, Hants.

Working time: unlimited.

Setting time: about 20 minutes at temperatures of 150-170°C

Shrinkage: unknown.

This was very convenient to handle although the cost produced was not as elastic as the other products tested. It did have some flexibility and produced excellent impressions with most filling materials.

Unfortunately, no longer manufactured.

CONCLUSIONS

1. Brummer, Polyfilla and Liquitex Modelling Paste were not suitable for use with the casting system tested.
2. Cellofas B + whiting and the gelatine/whiting/stand oil putty were highly receptive to the casting system used. Despite brittleness, they are potentially useful for use with a very weak paint film, where a strong filling would be undesirable. Shrinkage may be overcome by the repeated application of the filling layer.
3. Good cast impressions were made on Fine Surface Polyfilla; Aquapasto; Oleopasto; the National Maritime Museum putty and Plectol B 500 + whiting. The National Maritime Museum putty was more difficult to make up and handle than the others. Oleopasto had very unpleasant handling properties and was extremely sticky and slow drying.
4. The most successful casting materials were the two Reprosil products. Although these did not work as well with all the fillings as did the Vinagel, they were preferred because of their high flexibility and seem to be of great potential use.

It is hoped that these results will encourage further research in the field of casting surface textures. In addition to the application of casts for texturing fillings, they may be useful for casting deformation of paint surfaces and retained as a record during various stages of structural treatment.



Plate A

Cast and mould of deformed paint surface showing Sigmoidal cupping. (Above) Cast in Calspar dental plaster. (Below) Mould in addition cured Silicone Rubber, Reposil.

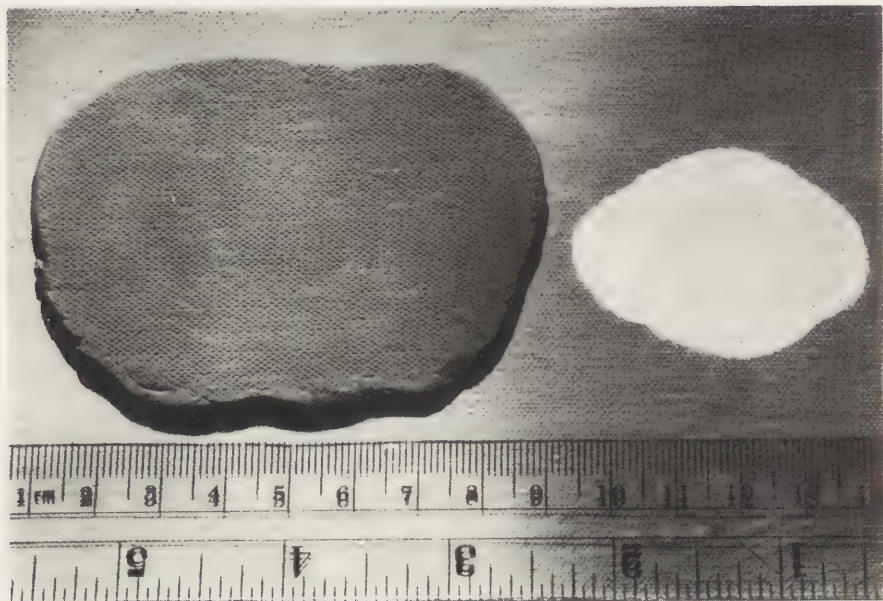


Plate B

Coloured primed canvas showing cast filling (Polyfilla).
Right hand side.

Mould in Silicone Rubber addition cured, Reprosil. Left
hand side.

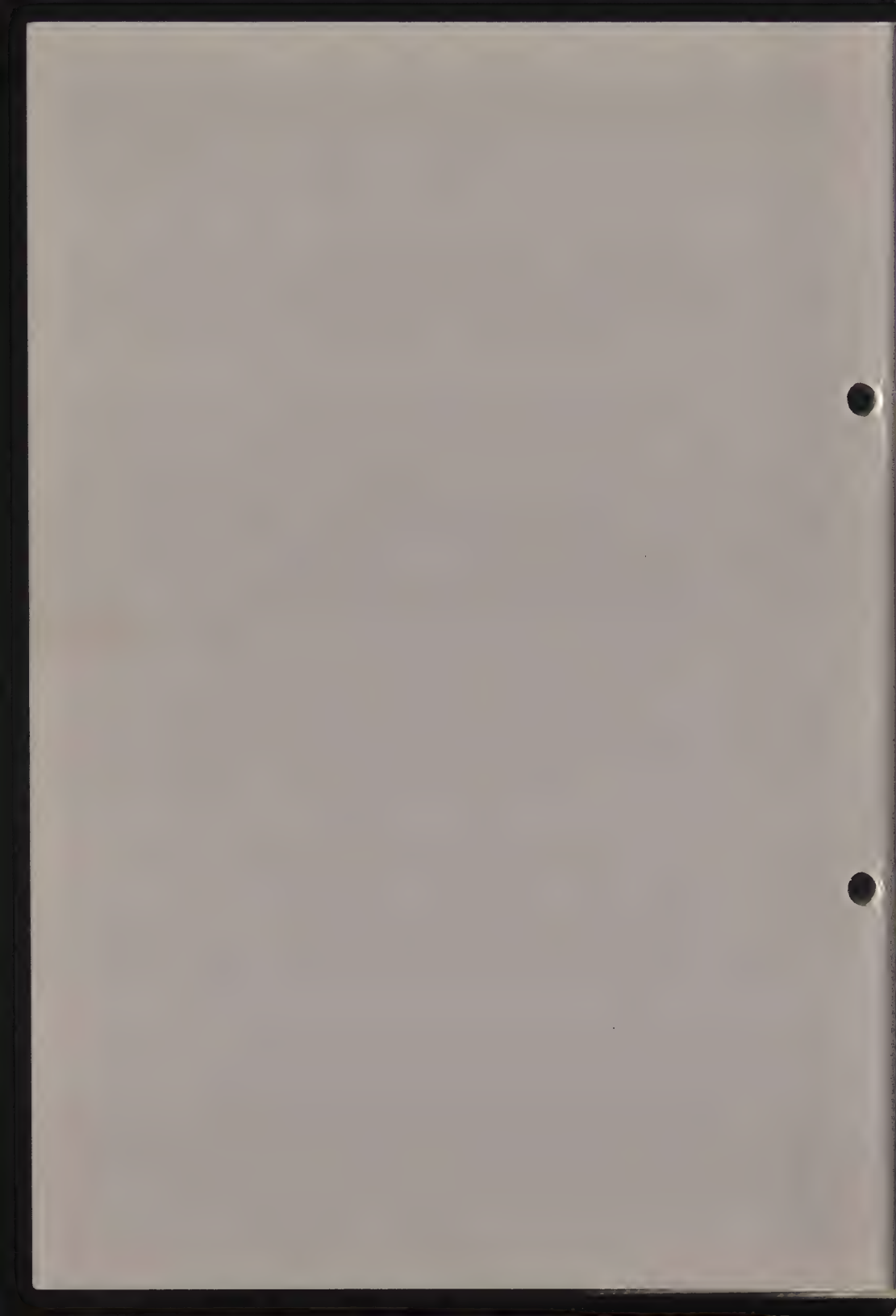
81/2/13

THE ADVANTAGES OF MOWIOL (POLYVINYL ALCOHOL):
COMPARATIVE STUDIES OF ORGANIC AND SYNTHETIC
BINDING MEDIA FOR FILLERS FOR PAINTINGS ON
CANVAS

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STUDIES OF ORGANIC AND SYNTHETIC BINDING MEDIA FOR FILLERS
FOR PAINTINGS ON CANVAS

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ABSTRACT

This study was prompted by the conservator's need to re-appraise traditional fillers for lacunae in paintings, few of which adequately meet the criteria, in particular the aging characteristics, now required by conservation science: that is, reversability, retention of flexibility and colour stability, and resistance to mould or decay.

A variety of binding media were considered, and formulations containing synthetic binders were compared with those formulations traditionally used, testing ease of handling and modelling, and minimal shrinkage tendencies. Mowiol 04-M1, an internally plasticized co-polymer of polyvinyl alcohol with a small amount of polyvinyl acetate, produced by Hoescht of West Germany, gave the best results of all the binding media, both synthetic and traditional, that were tested. The putty has good practical handling characteristics similar to the traditional formulations, but possesses much improved aging characteristics.

The author stresses that this research emerges from a practical conservation need: the practical application of the Mowiol filler has provided promising, but scientific data is necessary in order for polyvinyl alcohol to be

fully accepted as an alternative binder in painting fillers.

* * * * *

INTRODUCTION

The reintegration of the paint loss on a painting's damaged surface after stabilization begins with the introduction of a putty or filler into the lacunae. Even though these fillers do not preserve or conserve the material structure of the work and could be regarded as cosmetic, they meet important aesthetic considerations. Once the filler provides a surface plane uniform to the original, the resulting inpainted surface will present an undisturbed image.

It is vital that conservators consider the same objectives when selecting materials for a filler as they would when choosing an adhesive, a consolidant or a varnish for that painting. There are many properties to be considered in choosing a filler. The most important of these are the ease of handling and modelling, a minimal shrinkage tendency on setting, ease of removal without endangering the surrounding paint, and retention of flexibility and colour stability.

A wide variety of materials and their combinations are used in preparing fillers, and it is the binding medium which ultimately determines the final properties of the finished putty. The binding materials used in traditional fillers are far from ideal. Organic glues of vegetable and animal origin are subject to mould and bacterial growth. Although fungicides can prevent such growth, their effect is of limited duration. Furthermore, organic glues discolour and upon aging tend to become brittle or hard. However, when they are used in a putty as a binding medium, the resulting consistency and ease of handling make these traditional binding media desirable. Therefore, despite their long-term disadvantages, they are still commonly accepted. To date, little seems to have been done towards studying the properties of synthetic materials which could be used as alternative binding media in fillers.

In 1976, at the Central Research Laboratory for Objects of Art and Science in Amsterdam, the author participated in

a comparative study of organic and synthetic resins that could be used as binders for fillers.

THE SELECTION OF BINDING MEDIA FOR COMPARISON

Synthetic Binders

A preliminary study of available synthetic adhesives and resins served to screen out the obviously unsuitable materials. As a result, the two most promising synthetic resins, Plextol B500 and Mowiol 04-M1, were selected for the comparative tests. Both these binders were mixed with double-precipitated calcium carbonate, of the grade normally used in the pottery trade, to the most suitable putty consistency.

1. Plextol B500: An ethyl acrylate methylmethacrylate co-polymer emulsion, produced by Rohm of West Germany.
2. Mowiol 04-M1: An internally plasticized co-polyvinyl alcohol with a small amount of polyvinyl acetate, produced by Hoescht of West Germany.

A third synthetic material was also considered for the comparative tests because it had previously been used as a ready-made filler on a trial basis.

3. CRYLA: A prepared artists' acrylic primer, made by Rowney of the U.K.

Organic Binders

Four recipes representative of commonly used traditional fillers were selected (from four texts) for the first series of tests. These contain organic binding media such as animal glue, linseed oil, casein, and the resin dammar.

4. Linseed oil (Carl Dame Clark).
5. Gelatine and 10% linseed oil, half chalk recipe (Max Doerner).
6. Emulsion of casein with dammar resin in white spirit (Ralph Mayer).
7. Equal amounts of gelatine and stand oil mixed with 5% of beeswax by weight of the mixture (Helmut Ruhmann).

PLEXTOL	MOWIOL	CRYLA	CLARK	DOERNER	MAYER	RUHMANN
ADHERENCE						
CLEANING						
RETOUCHING						

Figure 1

TEST 1

For the first series of comparative tests, a stretched canvas was divided into seven vertical sections, with one section allotted to each prepared filler. (See Figure 1.) In most cases, the putties were applied in small patches (approximately 2 cm²) to the untreated canvas.

Similarly, the canvas was divided into three horizontal sections to correspond with the following three tests conducted with the fillers: adhesion, cleaning and inpainting. The consistency and handling properties, as well as shrinkage and drying time, were noted with the application of each putty.

Adhesion

Several different techniques of application were used on the top horizontal section, including the use of a knife, spatula, and brush and finger, and a variety of thicknesses resulted from these. Adhesion was noted as the filler was applied, by observing how the binding medium "wet" the canvas support and how the putty made contact with the canvas structure. After drying, adhesion was tested by subjecting the stretched canvas to mechanical stresses, and by attempting to lift edges of the filler with a scalpel.

Cleaning tests were intended to simulate the removal of excess filler during application and after drying. Cleaning techniques included the use of water, white spirits, isopropyl alcohol, and toluene. A preliminary test with methylated spirits indicated it was too harsh a solvent to be considered for testing. Smoothing and removal operations were also conducted with a scalpel.

Inpainting

This involved the use of the filler as a ground for various paint media.

Test 1: Results

Results of the tests were tabulated for all seven fillers and rated according to good, acceptable or poor performance. See Table 1.

FILLER NO.	1	2	3	4	5	6	7
<u>HANDLING:</u>							
consistency	*	*	+	*	*	*	.
adhesion	*	*	*	*	*	*	.
<u>REVERSIBILITY:</u>							
solvent	*
water	.	*
manual	*	*	.	+	.	.	.
<u>NO SHRINKAGE</u>	*	*	.	.	+	+	.
<u>SHORT DRYING TIME</u>	*	.	*	.	.	+	.
<u>RETOUCHING</u>	*	*	*	*	*	*	.

* good

+ acceptable

. poor

Table 1

1. The Plextol B500-based filler had excellent handling qualities and good consistency and adhesion. When wet it was removable with water, and when dry was easily scraped with a knife and swelled with isopropyl alcohol. It dried within one hour, with no apparent shrinkage.

2. The Mowiol-based filler gave the best results of all the fillers tested. Consistency and handling properties were excellent, and drying was complete within half an hour, with no apparent shrinkage. Wet or dry, it was easily removed with water, and when dry it was readily scraped with a knife.

3. The ready-made CRYLA, being liquid, proved suitable for very thin application only. The titanium white pigment content proved a disadvantage in that it was difficult to clean from surrounding areas. On application,

it soaked the canvas support. Drying was complete within half an hour, with some shrinkage. At least two applications of the material were necessary to produce a suitable filler. The dried consistency was very elastic, and mechanical removal was similar to scraping soft cheese. Solvent removal required toluene and was quite "messy".

4. The linseed oil-based filler exhibited good handling properties, but drying was very slow - two weeks - with substantial shrinkage. Dry removal was difficult, and only solvents which could endanger original paint could swell or soften the filler.

5. The gelatine with linseed oil-based filler had a smooth, creamy consistency and good adhesion. The linseed oil content required a two-week drying time, with severe shrinkage. For practical use, two or three applications with complete drying in between would be necessary. The dried putty was extremely hard, and even scraping with a scalpel blade was difficult. Any excess would have to be removed at the time of application. The dried filler was not affected by water or solvent action, and in practice the mechanical removal could be hazardous. The filler was harder than normal paint.

6. The casein-dammar emulsion-based filler had good handling and application properties. Drying was complete in one day, but with some shrinkage - especially noticeable in larger areas or thicker application, where splits and cracks formed. When dry, the filler was very hard and insoluble in acceptable solvents. Mechanical removal was difficult.

7. The stand oil, gelatine and beeswax mixture formed a dry pliable putty which was not readily applied to the canvas. The binding medium did not "wet" the canvas enough to allow adequate adhesion. The putty was inconvenient to make. Drying took just over one week, and with drying, the filler separated from the canvas and flaked away. In general, this was an unacceptable filler for the purposes of this test.

The first runs of these tests were conducted as soon as the fills were suitably dry. After six months a visual examination revealed that the three synthetic resin-based fillers had not undergone any evident colour changes. The remaining four fillers had yellowed considerably. Further reversability tests were repeated at this time,

with similar results to those determined in the original tests.

TEST 2

For the second series of tests, only the four fillers which were determined as acceptable by the first test were used. These were the Plectol, Mowiol, gelatine and linseed oil, and casein and dammar based fillers, respectively.

The properties investigated were as follows:

1. drying and shrinkage tendencies with varying thickness of application.
2. adhesion both to a wax-impregnated canvas surface (simulating conditions after a wax lining) and to an untreated canvas surface.
3. the effects of colour changes in the different fillers on the tones of the various inpainting formulations.

The stretched canvas was divided horizontally into two sections. (See Figure 2.) The upper portion was totally impregnated with beeswax, and the lower section left untreated. The four fillers were applied on four vertical sections of the stretcher by laying a strip of the putty (approximately 50 cm in length) at the left edge of the section. The putty was then drawn approximately 8 cm across the section, to the right, with a palette knife. The extreme left portion was very thin, and the extreme right portion thick. The build-up of thickness was gradual and fairly controlled.

oil impregnated canvas



untreated canvas



oil

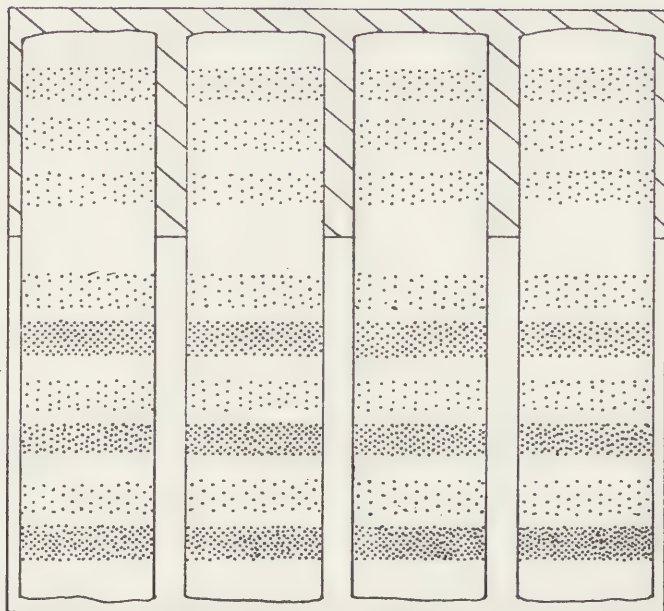
egg tempera

acrylic

oil

egg tempera

acrylic



transparent in-painting



impasto in-painting



Figure 2

Test 2: Results

As in the previous tests, all four filler putties exhibited good consistency and handling properties. All adhered well to the wax-treated surface, and drying times were the same as previously noted. The two synthetic-based fillers showed no apparent shrinkage, while the

other two did. The casein-dammar-based filler once again tended to crack on drying of the heavier impasto areas.

On the untreated lower section, results were much the same as in the first test series. However, with the larger area of application, the two traditional fillers produced appreciable distortion of the canvas support on drying. Even in the thick impasto areas, the synthetic resin-based fillers did not show shrinkage.

The retouching tests were conducted using an ultramarine blue pigment in oil, commercially prepared egg tempera, and acrylic based media. In the wax-impregnated section of the stretcher, the three paint formulations were applied as a thin glaze to the fillers. In the lower, untreated canvas section, the paints were applied to the fillers both as a transparent glaze and as a heavier impasto layer. This is illustrated in Figure 2. Under all oil retouches, an isolating layer was applied as follows:

- A 30% dammar in white spirit varnish was applied over the traditional fillers.
- A 25% Ketone Resin N in white spirit varnish was applied over the synthetic resin based fillers.

For the water-based paint formulations no isolating layer was necessary.

After six months natural aging in the laboratory, although the traditional filler had themselves yellowed, there was no visible alteration in colour of any of the paint formulations.

CONCLUSION

According to our results, the synthetic resin based fillers were judged more acceptable in all categories. Because of its solubility and reversability in water, the Mowiol 04-M1 based putty was chosen for continued experimentation and the use in on-going conservation treatment of paintings. This work continued at the Central Laboratory in Amsterdam and has now become an accepted alternative to the traditional fillers. The filler has also been used for painting conservation at the Swiss Institute for Arts and Science,

in Zurich, and on paintings and polychromed wooden sculptures at the Canadian Conservation Institute in Ottawa.

The two test stretchers are still being observed in the Amsterdam laboratory, where they are mounted on a wall which is not exposed to direct daylight. They are exposed, as well, to the laboratory fluorescent lamps. After some years, the observations will be compared with the original results, and final conclusions drawn at that time.

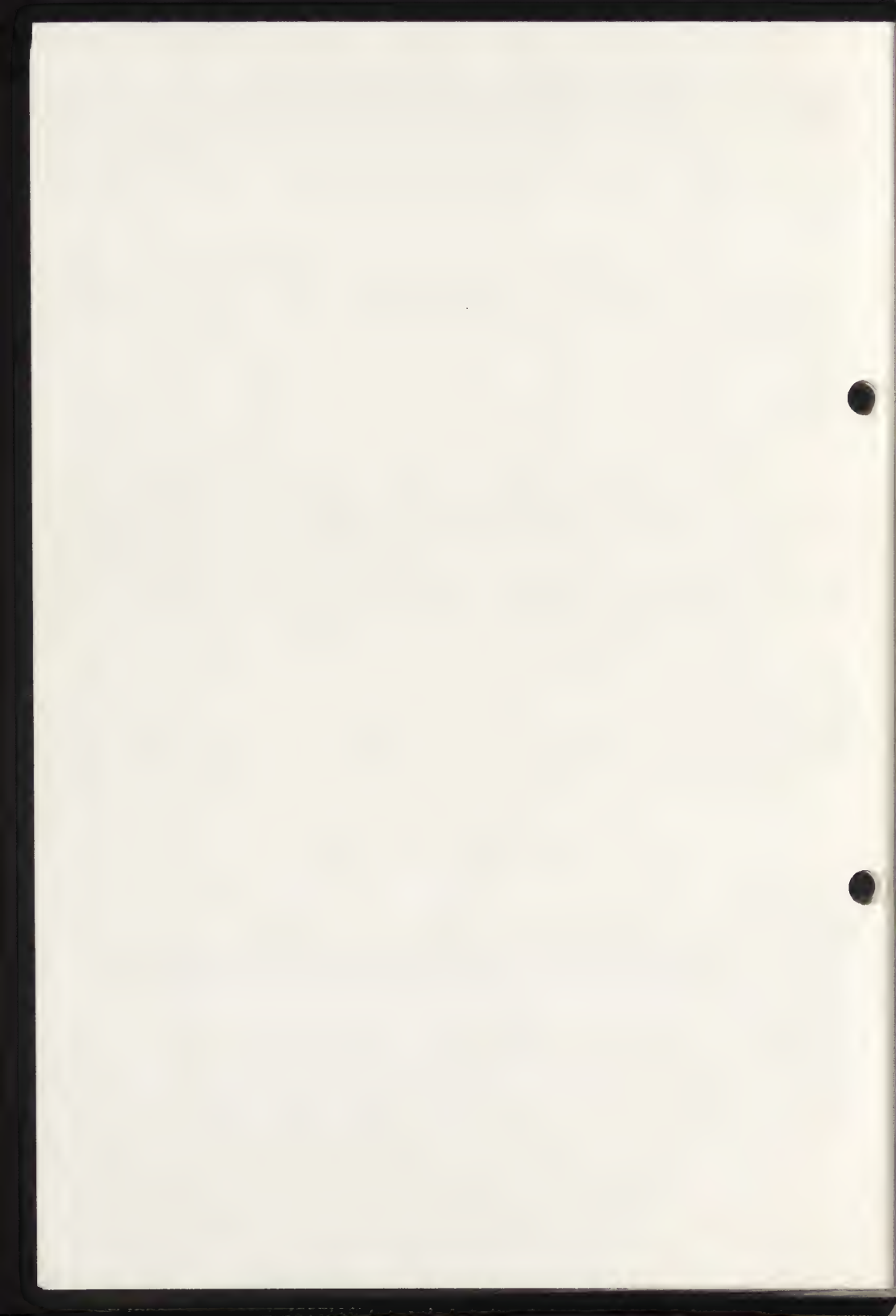
To conclude, I would like to emphasize that this beginning comparative research has been carried out from a practical conservation point of view and that a follow-up to substantiate my findings is invited, especially for more scientific data relative to the study of alternative filler binders in paintings.

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I am grateful to Mr. J. Lodewijks, former Director of the Central Research Laboratory for Objects of Art and Science, Amsterdam, Holland, for the opportunity to carry out these experiments; to other staff members of the laboratory, especially Mr. R. Munnikendam and Mr. R. Krefkeur, for their invaluable chemistry background. I am very thankful to Mr. V.R. Mehra who initiated the tests, giving much guidance throughout; also Mr. IJ. Hummelen, who continues tests in Amsterdam and who introduced the Mowiol putty formula to Zurich.



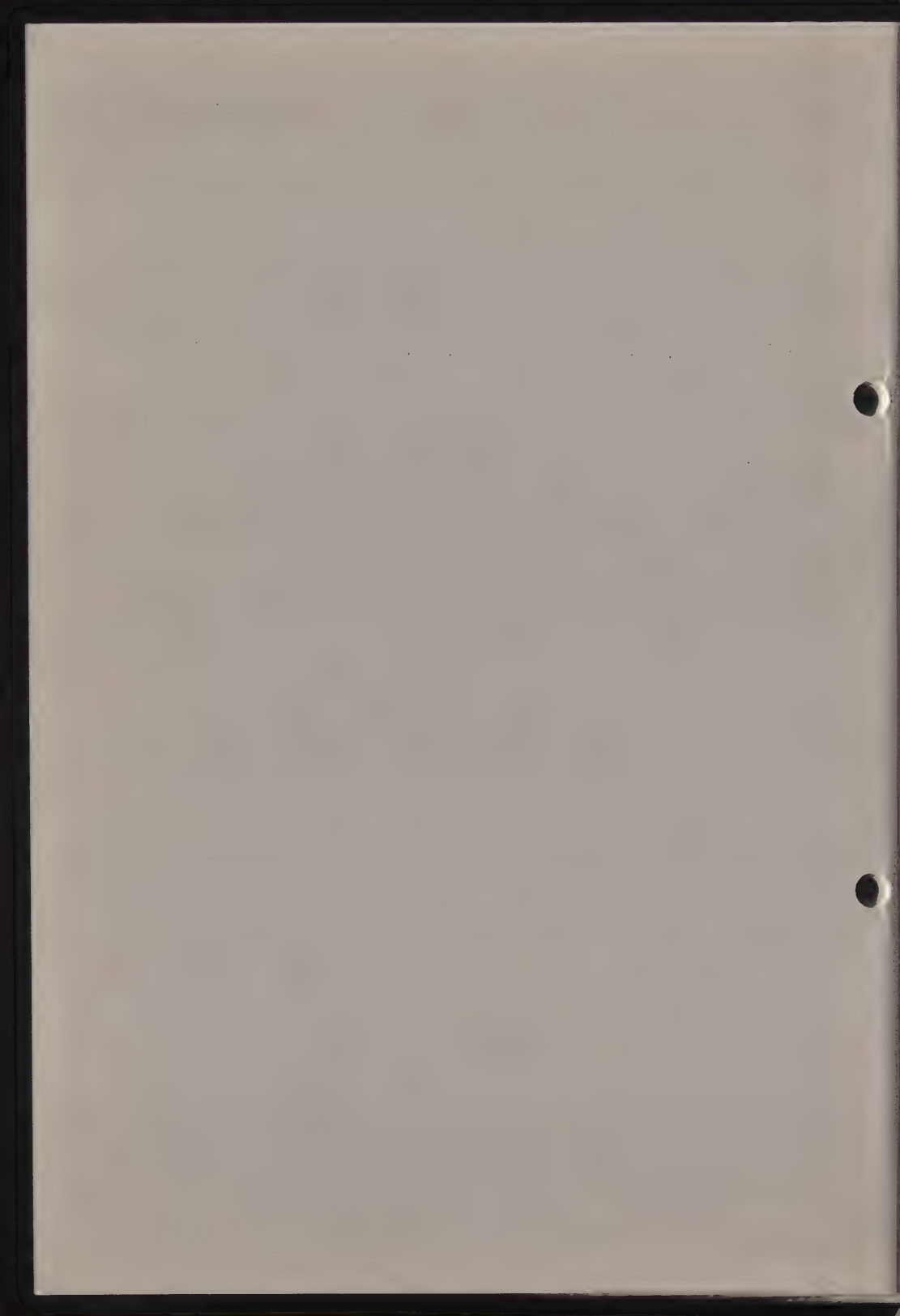
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MINIMIZING STRAIN AND STRESS IN LINING CANVAS
PAINTINGS

V.R.Mehra

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Structural Restoration of
Canvas Paintings



MINIMIZING STRAIN AND STRESS IN LINING CANVAS PAINTINGS

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Abstract

While working on the development of the cold-lining method for canvas-paintings, as it occurred at the Central Research Laboratory for Objects of Art and Science in Amsterdam, Holland, during the past decade, the author realised that, apart from making an effort to achieve a safer lining system, something should be done about reducing strains and stresses inherent in every lining process. Initially, attention was focussed mainly on finding a lining adhesive and a lining fabric which would stand up to a set of prefixed requirements, as listed in previous publications presented to ICOM. Research resulted in the selection of a number of synthetic materials which went a long way in passing tests relevant to the purpose. Yet, some studies undertaken by colleagues like Tassinari, Hedley and Parrini suggested that the mechanical properties of the woven synthetic fabrics finally selected as lining support ought to be improved. Within that frame of thought the author makes a few remarks.

Introduction

Doubts with regard to the conventional lining methods and materials for canvas paintings have been with us for quite a while. Already in the early 1960's conservators experimented with synthetic fabrics which might eventually serve as alternative lining supports. One such material was glass fibre which promised to have excellent properties. Yet, attempts at introducing glass fibre as a lining support remained restricted, and it is easy to understand why: it does not allow easy handling and its appearance is rather foreign to the looks favoured by tradition. Realising this we have never seriously considered glass fibre as a lining attribute when we began our studies towards the development of the so-called cold-lining method, a project which was started ten years ago and which was meant to create an alternative lining method for those conservators who have become increasingly critical of disadvantages inherent in the use of conventional methods and materials: wax-resin and starch glue as adhesives, and, as a rule, hemp-canvas as a lining support. Instead, we experimented with a range of synthetic adhesives and synthetic fabrics, such as polyester, polyamide and polypropylene. As to the fabrics, we found some types to be acceptable mechanically as well as aesthetically, finally favouring a particular kind

of polypropylene which, apart from standing up to our requirements in a mechanical sense, was least foreign to natural canvas in terms of appearance. We found this latter consideration to be of importance, since a general reluctance to make use of synthetic fabrics and adhesives in lining canvas-paintings was also based on a certain measure of prejudice born from a traditionally grown sense of what is and what is not found to be acceptable to the eye. Yet, after Tassinari, Hedley and Parrini published the results of their studies concerning the mechanical behaviour of polypropylene and some other synthetic fabrics, incidentally employed by us in cold-lining, it became clear that there is room for further improvement.

In our paper presented at the ICOM-conference held in Zagreb in 1978 ("Cold-lining and the care of the paint layer in a triple-stretcher system") we have suggested that certain problems with regard to strains and stresses in canvas paintings should be studied more thoroughly. To this end we suggested that a working group should be formed which would dedicate itself to those studies. This idea took shape in Zagreb where the Committee for the Care of Paintings named a team consisting of staff members of the Courtauld Institute of Art in London and the Central Research Laboratory in Amsterdam. London was to take care of theoretical studies, Amsterdam would look at the problems from a practical point of view. Results of work done so far by the Courtauld Institute are reported in a paper by Gerry Hedley ("The Stiffness of Lining Fabrics") found elsewhere in this volume. Our own preliminary observations derived from some experimental work done during the past three years, are stated below:

For most purposes, woven synthetic fabrics generally have good mechanical and chemical properties. But what is often lacking is a certain measure of stiffness to reduce extensibility or elongation of the fibres. And since all lining methods for canvas paintings inevitably involve stretching (unless use is made of marouflage which is an effective technique but at the same time means the introduction of virtual change in the character of a canvas painting), a lining support should be properly resistant to the kind of strains and stresses caused by that stretching. Also, just like any natural canvas material, woven synthetic fabrics are usually anisotropic, meaning that they extend differently along warp and weft, which may cause stresses in such fabrics which could get transferred to the painting canvas when used for its lining. Research done so far seems to indicate that this kind of disadvantage in the lining of canvas paintings with synthetic fabrics can be eliminated only when the idea of using woven synthetic fabric is discarded altogether. Unless, of course, a formula can be found for the manufacture of such fabrics which would render a perfectly, at least sufficiently isotropic material. But, as

far as our information goes, industry has not yet produced any woven synthetic fabric which satisfies such demand. Possibly we should study the quality of monofil fibres, as suggested by Hedley in his paper mentioned above, and evaluate their eventual usefulness for the specific purpose of lining.

Although we have not yet found any serious defects in the many cold-linings we have practised during the past decade while using synthetic fabrics as supporting material, it is clear that we may not disregard the outcome of technical studies undertaken by Tassinari, Hedley and Parrini, suggesting that the mechanical behaviour of these fabrics requires improvement. We therefore believe that, apart from trying to undertake studies which will foster such improvement, we should further explore the feasibility of using compressed synthetic materials. There are quite a few types of such materials available and they are known to have properties which may quite well stand up to the requirements involved in the lining of canvas paintings. But, again, many conservators would probably refrain from considering their use, because the appearance of such materials does not suit their sense of aesthetics, even though it is usually the painting which meets the eye while its supporting material faces the dark of a wall. In our view the use of non-woven synthetic materials, even though their appearance may aesthetically seem to be unbecoming, should not be rejected out of hand and we, concerned with the improvement of the quality of lining in general, must be determined to put their suitability to the full range of relevant tests.

In the meantime, however, we have made attempts to achieve reduction of the extensibility of the synthetic fabrics employed in cold-lining, and we have done so by applying an artist's ground on the one side of the lining fabric which, after lining has been carried out, remains the rear of the lined painting. By doing this we found that a certain measure of stiffness was obtained and - that being our goal - we set up a testing programme in order to evaluate the mechanical behaviour of such pre-treated lining canvases following approved standards. The practical part of the work was done at the Central Research Laboratory, while the testing proper was carried out at the Courtauld Institute.

It was interesting to note that the extensibility of nearly all types of synthetic fabric had considerably reduced after they had been prepared with an artist's ground (see Tables 1, 2 and 3). As compared to tests done on raw, unprepared synthetic fabrics, a substantial decrease in weight load strain was observed.

Yet, the results of these tests should be considered as being preliminary. Because it is quite difficult to compare different materials when they do not have the same weight, vary in weave pattern and, above all, consist of different kinds of fibre. Apart from decreased extensibility no significant

change in isotropic behaviour could be detected. Yet, this aspect needs further study. What we need to know is whether the application of an artist's ground on the lining fabric changes the general behaviour of that fabric, and if so, at what weight load such ground retains its effectiveness, or to what extent the inherent mechanical characteristics of a fabric remain dominant. For the moment we have to be satisfied with the knowledge that the application of an artist's ground does add to the required stiffness and that it protects the synthetic lining fabric against exposure to direct light and climatic change. Concerning this last issue it is interesting to see what is observed by Stephen Hackney of the Tate Gallery in his paper entitled "Deterioration of modern painting canvas supports" which the author presented at the "Symposium on the Conservation of Modern and Contemporary Art", held in Ottawa, Canada, July 1980.

Conclusion

Of all measures taken by the conservator to help extend the period of survival of a canvas painting, lining, which is inevitable at one time or another, can be considered the most drastic one, technically as well as mechanically. Lining may improve a painting's condition, but it may just as well enhance its deterioration when methods and materials are used which do not agree with a painting's own character and mechanical properties. Conventional lining methods, as they were practised during the past two centuries and are still in practice today, have certain acknowledged deficiencies which warrant elimination. The Central Research Laboratory has introduced a lining system which tries to offer an improvement, a technique purely based on the use of synthetic materials. Although it has taken us a decade to refine this technique to the point where colleagues all over the world start sharing our own confidence in its effectiveness and its qualities, there is still room for betterment. In our mind it is beyond question that the use of synthetic materials in lining is to the benefit of a painting's durability. Yet, the quality of the materials available, particularly the fabrics which may serve as lining support, must be improved. When a lining is undertaken it is, in our view, important to minimize the strains and stresses which inevitably occur. We may achieve that by selecting a lining canvas which has a certain stiffness, or by improving the suitability of a lining canvas through application of a ground on it, as though it were an artist's canvas. Although the latter does not improve the isotropic behaviour of the canvas, it does add to stiffness which will counter the strains and stresses to which the canvas will be subjected during lining. Of course, if we could improve the isotropic behaviour of the canvas we would have solved all our problems. But, technical studies have established that all woven fabrics, also the synthetic ones, are subject to undesired anisotropic behaviour when exposed to strains and stresses which are part of the lining process. It is our task to find

ways and means which will improve the isotropic behaviour of those fabrics, or to resort to the idea that the employment of compressed (non-woven) synthetic fibres as lining support may finally prove to offer the most appropriate alternative to natural canvas materials, even if such a conclusion may meet with hesitance on the part of aesthetically over-conscious conservators. Anyway, the ICOM working group on strains and stresses in canvas paintings and their lining fabrics intends to proceed with its studies and hopes to report further at the forthcoming ICOM-conference three years from now.

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Table 1. Measurement at 2 kg weight

Material	Strains (%) for raw material		Strains (%) for material with ground		Decrease in weight load strains due to ground		Isotropic behaviour of material	
	A	B	C	D	$(1-\frac{C}{A})100\%$	$(1-\frac{D}{B})100\%$	B/A	D/C
	Weft	Warp	Weft	Warp	Weft	Warp	Raw	With ground
Linen	3.0	8.5	1.6	2.6	47%	69%	2.8	1.6
Cottonduck	3.9	3.0	1.0	0.7	74%	77%	0.8	0.7
Polypropylene "A"	2.6	5.9	0.7	1.0	73%	83%	2.3	1.4
Polypropylene "B"	4.3	5.9	0.7	0.8	84%	86%	1.4	1.1
Polypropylene "C"	2.6	1.0	0.3	0.1	88%	90%	0.4	0.3
Polyester "A"	1.6	1.6	0.7	0.3	56%	81%	1.0	0.4
Polyester "B"	2.6	1.3	0.7	0.3	73%	77%	0.5	0.4

Table 2. Measurement at 4 kg weight load

Material	Strains (%) for raw material		Strains (%) for material with ground		Decrease in weight load strains due to ground		Isotropic behaviour of material	
	A		B		$(1 - \frac{C}{A})100\%$		$(1 - \frac{D}{B})100\%$	
	Weft	Warp	Weft	Warp	Weft	Warp	Raw	With ground
Linen	3.9	11.5	3.6	7.2	8%	37%	2.9	2.0
Cottonduck	4.9	4.9	6.6	2.5	35% in-crease	49%	1	0.4
Polypropylene "A"	3.9	9.2	1.3	3.3	67%	64%	2.4	2.5
Polypropylene "B"	5.9	6.6	1.6	2.3	73%	65%	1.1	1.4
Polypropylene "C"	3.8	1.6	1.0	0.4	74%	75%	0.4	0.4
Polyester "A"	3.0	2.3	1.2	1.1	60%	52%	0.8	0.9
Polyester "B"	3.6	2.3	2.0	0.8	44%	65%	0.6	0.4

Table 3. Measurement at 10 kg weight load.

Material	Strains (%) for raw material		Strains (%) for material with ground		Decrease in weight load strains due to ground $(1 - \frac{C}{A})100\%$ $(1 - \frac{D}{B})$		Isotropic behaviour of material	
	A	B	C	D	Weft	Warp	B/A	D/C
	Weft	Warp	Weft	Warp	Weft	Warp	Raw	With ground
Linen	4.9	15.8	5.3	13.5	8% in- crease	15%	3.2	2.5
Cottonduck	6.6	8.5	10.8	5.4	64% in- crease	36%	1.3	0.5
Polypropylene "A"	7.6	15.7	5.2	9.8	32%	38%	2.1	1.9
Polypropylene "B"	9.2	10.5	4.6	6.2	50%	41%	1.1	1.3
Polypropylene "C"	5.7	3.0	3.0	1.3	47%	57%	0.5	0.4
Polyester "A"	6.0	4.1	4.3	2.6	28%	37%	0.7	0.6
Polyester "B"	6.6	4.9	5.6	2.6	15%	47%	0.7	0.5

ETHNOGRAPHIC MATERIALS

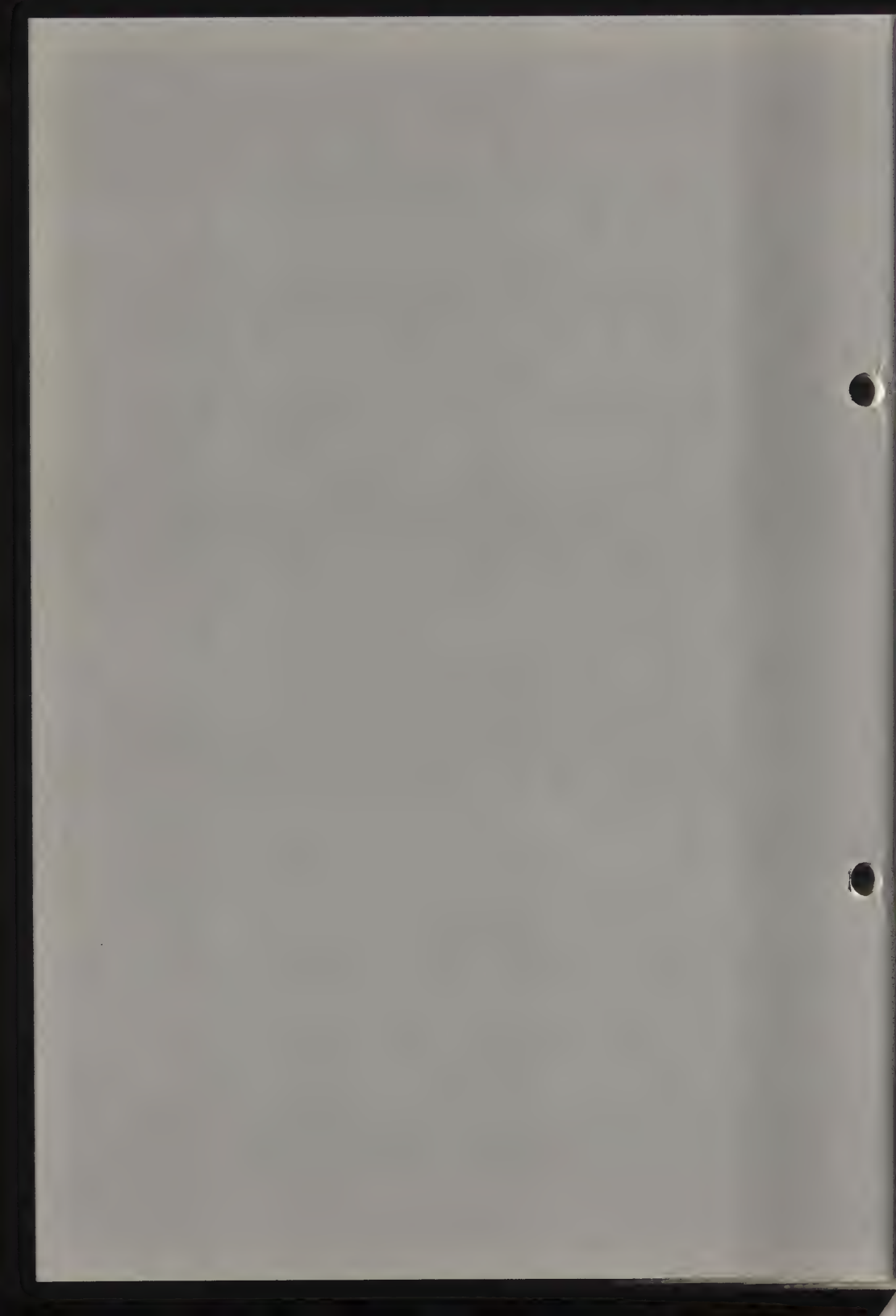
Coordinator : W.P.Bauer (Austria)

Assistant coordinator: E. Schaffer (Canada)

Members : A. Bakken (Norway)
 B. Coursier (France)
 K.A.Fritsch (FRG)
 H. van Geluwe (Belgium)
 H.V.Gowers (U.K.)
 G.H.Grosso(USA)
 I. Kiziltan (Turkey)
 M.-O. Kleitz (France)
 R. Renshaw-Beauchamps (Canada)
 S. Şişmanoğlu (Turkey)
 J. Stone (USA)
 D. Tilbrooke (Australia)
 G. Vindry (France)

Programme 1978-1981

1. Bark-cloth-conservation and preservation of fibre materials; treatments without removing colours (Bakken, Gowers and Grosso).
2. Skin-conservation (Indian clothes); research on glueing-agent identification of dye-stuffs (Schaffer).
3. Investigation on epoxy-resins, kautschuk etc. for consolidating ethnographic objects (Behavior against photochemical destruction) (Kleitz).
4. Conservation of leather and skin-objects; Combination of tannins with collagen, type of bonds and how they are affected by environmental factors (Tilbrooke).
5. Different adhesives in the restauration workshops of ethnographic museums (Renshaw-Beauchamps).
6. Safety precautions and international rules for the use of insecticides in ethnographic collections for pest control (List of toxicity...). Behavior of ethylene oxide on objects influence of vacuum (Bauer).
7. Studies of ancient handicraft (Şişmanoğlu, Kiziltan).
8. List of literature and index of publications of conservation of ethnographic materials (Fritsch).
9. Biocides - practical use - effect on paper and objects (Stone)



REPORT ON THE ACTIVITIES OF THE WORKING GROUP 'ETHNOGRAPHIC MATERIALS' 1978-1981.

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Conservation and Restoration of Artifacts made of cellulosic Materials: Basketry and Bark Cloth Conservation

At the Zagreb-meeting 1978 we started the discussion about this special kind of field with two papers (A.Bakken, E.Schaffer). This was a very good beginning, and also during the last three years our special attention was concentrated upon this object. Good basketry- and bark cloth conservation is of basic interest to all ethnographic museums. The attempt at continuing this work was realized in presenting 5 papers at this meeting, concerning practical treatments of tapa-clothes and basket work, tests of different adhesives for basketry and wicker work. One paper is a scientific report on the identification of vegetable fibres in Canadian ethnographic woven artifacts.

Adhesives in the Restoration Practise of Ethnographic Museums

Of special interest for the work-a-day restoration are adhesives and mending pastes, offered by the industry. All of us know that they have often had disadvantages in practise. Three papers are dealing with this problem, one in connection with restoration of basketry work (Hartley/Grosso), one regarding the restoration of textile fragments on glass (Kleitz), and the last one is more a philosophical reflection (Renshaw-Beauchamp).

Climatic Conditions: Risk for Mould Growth

A handicap - most of the ethnographic museums are struggling with it - is to preserve their collections against mould growth. Under unfavourable conditions objects of organic materials are running risks to get attacked by moulds, specially objects made of vegetable and animal fibres, leather and wood. The first step to an optimal preservation has to be done by establishing better climatic and environmental conditions in storage rooms as well as in displaying rooms. However, money is often lacking for installing an air-conditioning plant. What could be done in this case? Walston/Casey (Australia) are working on this problems since 1979, concentrating upon isolation and identification of fungi. A study was initiated to monitor the microenvironment immediately adjacent to objects on shelves and relate these data to ambient conditions in the air-conditioned storeroom and external environmental conditions. Also the effect of water activity on the growth of the moulds is examined, furthermore the depth of hyphal penetration. The study will give a better understanding for the complex interaction that exists between microenvironment, nutrients and species of mould.

Pest Control in Ethnographic Museums

This leads over to another important aspect in the work-a-day conservation in ethnographic collections: the pest control. Two papers dealing with the subject of using fumigants for pest control in museums were presented at the Zagreb-meeting. They gave a fundamental survey and were starting-points for discussions about the different systems, as well as about advantages and disadvantages of different fumigants, the effect of vacuum on the objects etc. For this meeting it was planned to carry out investigations on the influence of ethylenoxide on objects, possible changing of colours and effects of the fumigants in other regards. Labworks on this problems are difficult and cannot go on as quick as requested. Investigations are carried out by DEGESCH (Fed. Rep. of Germany) and the A.T.P. in collaboration with Centre National de Scientifique (Paris), but they have not been able to get ready till now. Besides of treatment with gasses the use of insect repellents for protection of museum objects is important; one paper at this meeting is dealing with this problem (Zaitseva).

State of Conservation of Art Objects in Ethnographic Museums

The necessity of scientifically founded restoration as well as of analytical research on objects in ethnographic museums was not realized earlier than two centuries ago. Previously scientific research activities with a few exceptions were concentrated only to the restoration of objects of fine art and archaeology. Therefore especially smaller ethnographic museums are often lacking of trained personal and frequently only a small staff (in the worst case one or two persons) is responsible for a lot of restoration work. To improve this situation the ICOM and joint organizations attempted many things, particularly concerning the training of restorers. Nevertheless, in my opinion the amount of restorers should be increased in order to have enough people specially skilled and trained for every kind of material existing in ethnographic museums. The restoration facilities ought to be improved, too. We hope to realize these intentions with the aid of ICOM and especially the Conservation Committee.

Acknowledgements

I wish to express my sincere thanks to the authors of the papers, who have spent a lot of time in preparing their contributions and for all work, scientific and practical, that was done in the last three years to support the activities of the working group. I am also very grateful to all other members of the working group for their cooperation and for useful informations. Through their help we could expect a good and successful meeting. I hope it will provide all curators in ethnographic museums with a better understanding of the problems of conservation of cultural property.

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ADHESIVES FOR BASKETRY CONSERVATION:
PRELIMINARY TESTS

E.J.Hartley and G.H.Grosso

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Working Group: Ethnographic Materials

ADHESIVES FOR BASKETRY CONSERVATION: PRELIMINARY TESTS

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Abstract

Discussed is the relative lack of basketry conservation information in the literature. Described is an experiment in testing adhesives which might be used in basketry conservation and evaluations of their strength, flexural rigidity and reversibility.

Introduction

Research on basketry conservation is badly needed. There is little information on basketry conservation in the literature as represented by references in Art and Archaeology Technical Abstracts. Basketry is not even listed separately in the abstracts: articles on baskets may be included under the categories "WOOD," "FIBERS and TEXTILES," or "OTHER NATURAL and SYNTHETIC ORGANIC MATERIALS." Wood conservation information and technical data is rarely applicable to baskets, as basketry materials are seldom full-growth wood, and much use was made of non-commercial woods, as well as various non-woods (e.g. grasses.)

Baskets are not true textiles, being woven off-loom and with fibers seldom processed far enough to be termed "yarns." Some basketry materials are listed as non-commercial fibers (e.g. raffia), but baskets in general are much less flexible than textiles and lack the related properties of "drape" and "handle." Technical data on textile materials and textile conservation methods are rarely applicable to basketry.

Baskets are an important part of the ethnographic record, if only because of their numbers. There are large quan-

titles of baskets in public and private collections, some of which seem to have survived in spite of storage and display conditions or past "conservation" treatment. With the amount of material which needs or will need conservation work, there is a need for basic research into materials and techniques for cleaning, repair, humidification and protection of baskets.

A search of the literature turns up the following list of articles dealing with or related to basketry conservation:

Gibson, Bethune, "Use of the airbrasive process for ethnological materials," *Studies in Conservation* :14(4) 115-64 (1969).--A description of the cleaning of basketry using air-driven dolomite powder or glass beads.

Foreman, Louise, "Preserve and protect your American Indian Baskets," *The Masterkey* :45 (2) 56-63 (April-June 1971).--Instructions for the small-time collector of baskets, including washing, steaming, reshaping, storage and display.

Pomerantz, Louis, "The lining treatment of a painted cedar mat," *Bulletin of AIC* :16(1) 45-46 (Winter 1975-76).--A description of the treatment of an individual specimen by lining it with a supportive material.

Shaffer, Erika, "The preservation and restoration of Canadian ethnographic basketry," *Studies in Conservation* :21 (3) 129-133 (1976).--A description of the use of a hygroscopic solution to maintain or restore the moisture content of displayed baskets.

Florian, Mary-Lou, "Plant material used in some ethnological artifacts, structure, fabrication and deterioration related to conservation treatments," *AIC Preprints* (May 30-June 2, 1977 meeting) --A discussion of the identification of basketry materials, their physical and chemical characteristics, deterioration processes and how these relate to possible conservation treatments, and possible effects of the conserving agents on the fibers.

Volf, Sara J., "Caring for your basketry collections," *American Indian Art Magazine* :2 (2), 18-19 (Spring 1977).--Discusses problems caused by dirt, mold and changes in humidity. Recommends spraying baskets with a 5% solution of glycerine in ethanol and describes a humidification and reshaping process.

Wolf, Sara J., "A survey of basketry cleaning methods," *American Indian Art Magazine* :2 (3), 24-25 (Summer 1977).--Recommends gentle brushing, use of vacuum with brushing, swabbing with dry cleaning solvent to remove waxy or oily materials or the use of an air abrasive machine.

Turnbaugh, S.P., "Common sense care of baskets," *Shuttle, Spindle and Dyepot* :9, 90-93 (Summer 1978).--Proper handling and cleaning guidelines for handmade baskets.

Bakken, Arne and Kirsten Aarmo, "A report on the treatment of museum materials made of plant fibers," *Preprints ICOM Committee for Conservation*, 5th (Zagreb 1978) :78/3/2/1-4.--Description of the washing and humidification with polyethylene glycol 400 in a 10% aqueous solution on a Samoan mat.

Bauer, W.P., "Report on the activities of the working group 'ethnographic materials'," *Preprints ICOM Committee for Conservation*, 5th (Zagreb 1978) :78/3/2/1-2.--Comments on lack of material on basketry conservation and need for research in this area as well as for other miscellaneous organics.

This list represents an average of less than one article published recently on basketry conservation every year. This is ironical: lots of baskets but little information as to their conservation treatment. There are three possible reasons for this: 1) basket collections are not being treated; 2) the methods of treatment being used are considered so basic as to not necessitate publication; or 3) the conservation treatment of baskets is a "catch-as-catch-can" affair and is not organized enough to warrant publication. It is the purpose of the authors to begin to deal with the lack of information on the conservation of baskets by conducting standardized tests on a number of adhesives already used in, or possibly suited for, basketry conservation.

The basic requirements for an adhesive for basketry repair are strength and flexibility. A glued joint should not fail under its own weight or on application of nominal "normal" pressure. It should be able to flex to some degree without failure and without stress on the surrounding basketry materials. An adhesive suitable for basketry conservation should also: 1) be applicable in small amounts; 2) be easily reversible without damage to the basket materials; 3) remain stable (i.e. reversible, resistant to color change) over long periods.

of time, and (3) have a good appearance. In addition, for convenience, the adhesive should have a fairly short set-up time (hands usually are used as clamps in basketry repair), a fairly long pot life, and be easily available at a reasonable price.

Some examples of adhesives in use now are: a mixture of methylcellulose and wheat paste ("Secondary Paste") (1) used by the Conservation Laboratory of the British Columbia Provincial Museum; Magic Meni, a polyvinyl acetate emulsion, used by the Anthropology Conservation Laboratory of the Smithsonian Institution and Pacific Northwest Conservation Laboratory; and Elmer's Glue-All, a polyvinyl acetate emulsion, often used in gross amounts by collectors and dealers.

In the preliminary selection of adhesives for testing, only three of the requirements listed above---strength, flexibility and availability at reasonable cost---were looked for. The preliminary list of adhesives included Elmer's Glue-All, Magic Meni, Conservation Materials' (2) polyvinyl acetate emulsions (M Bond M-1, M-2, M-3, M-4, W- ; the polyvinyl acetate resins AYAA, AYAC, AYAF and ASAT; "Secondary Paste," Glico Cement and Scotch Super Tensile Adhesive.

Test Procedure

The rippling bark of Western Red cedar (*Thuja plicata*), a material widely used in Pacific Northwest basketry, was chosen as the subject material for the adhesive testing. The bark used had been collected two years ago on the Olympic Peninsula of the State of Washington. It had been folded for storage and was soaked in water to restore flexibility, both standard practices of Native American basket makers of the region. The bark then was cut into 18-in. lengths with a utility knife (heavy duty razor blade in a handle) and split to approximately equal widths of 7mm (1/4 in) along the grain by drawing the bark between a blade and a straightedge. The resulting strips then were hung with weights to straighten them. Next they were immersed and split to about half their original thickness with a final dimension of approximately .7mm using a pocket knife to start the splits. Finally, the strips were placed between absorbent paper and books were placed on top to flatten them during drying. Some strips still curved along all or part of their lengths.

Characteristics to be tested on the adhesives were their tensile strengths and bending abilities. The most often

encountered damage found in baskets involves breaks in individual weaving elements. Therefore a simple butt join is the most usual problem. This type of join also is the most difficult to achieve successfully in any kind of joinery.

The split strips of cedar bark were sorted to select as uniform a group as feasible. Then the sample strips were cut across the grain using an X-acto knife against a hardwood block. This produced a clean, uncompressed, perfectly matched join; one seldom found in broken baskets. Each of the simulated breaks was marked to insure mating, joined with an adhesive and labeled as to which adhesive was applied. A total of 8 joins, four each for two strips, was made with each of the adhesives tested. Cross-sectional dimensions were taken for each join so that more valid comparisons could be made between the joins despite the variations in width and thickness of the cedar bark strips.

The adhesives were applied with a 000 watercolor brush. For the PVA emulsions and "Secondary Paste," each half of the join was given a thin coat of adhesive. The PVA resins and the Duco and Scotch adhesives required another coat on one half in order to obtain a bond. The halves were held together until the bond would hold the weight of the strip joined (3.3 to 7.5cm long), then laid on a flat surface to dry. The time required for a join to set varied from 15 seconds to almost a minute. With broken baskets there is often tension on the break, requiring longer holding time in order to obtain a good join.

Preliminary testing carried out on reject strips led to a reduction in the number of adhesives tested. Reasons for rejection were inability to obtain a bond, inconsistency in bonding or failure of a bond while handling in preparation for testing. The adhesives finally selected for testing were: Magic Mend, Elmer's Glue-All, the CM Bond adhesives M-2, M-3, M-4 and W-2, the PVA resins AYAF and AYAT, Duco Cement, Scotch SuperStrength and the Glapp "Secondary Paste." Magic Mend, Elmer's Glue-All and the CM Bond adhesives are proprietary polyvinyl acetate emulsions. Elmer's Glue-All (The Borden Co.) is an all purpose glue. Magic Mend (Delkote, Inc.) and CM Bond W-2 (Conservation Materials, Ltd.) are book binding adhesives. CM Bond M-2, M-3 and M-4 are described as being specially formulated for conservation use and W-2 is listed as suitable for textile and paper conservation (3). The PVA resins AYAF and AYAT (Union Carbide) are supplied in pellet form and are dissolved in acetone for use. Duco Cement (du Pont) and Scotch SuperStrength (3M) are believed to be nitrocellulose type adhesives. The

Clapp "Secondary Paste" is a mixture of wheat paste and methylcellulose

Data sought in the tests were: 1) tensile strength of a join as prepared; 2) bending strength of a join; 3) the tensile strength of a join after it had been bent, and 4) the reversibility of the glued join in acetone and in water.

Tensile strength figures were obtained by placing each strip in its appropriate series in a strength testing apparatus. Three of the four joins were stressed to failure and the pull required recorded from a mechanical force gage. The fourth join was used to test the reversibility of the adhesive in acetone.

Measuring the tensile strength required a special apparatus to be built in the laboratory shop. It consists of a wood platform slightly lower than the pan of a balance, an adjusting screw for regulating the height of one side of the platform, a machined steel block and several weights. The platform is a solid piece of wood c. 15cm tall and 8.5cm on each side. The regulating screw allows for c. 1cm total adjustment. The steel block was made from a piece of 1/4-inch thick plate and is about 3cm long and 3cm wide. After the edges were surface-ground to plane surfaces, one edge was ground off at a 12-degree angle starting 13mm from the end. A gage was fabricated from light sheetmetal and installed to indicate a 10-degree arc. In use, a join to be tested was placed on the top of the platform with the join extending over the edge by 6.5mm. The steel block then was placed on the strip with the beginning of the ground angle over the join. Weights were placed to hold everything steady. Then the screw was adjusted so that a point on the cedar bark strip 26mm from the join just touched the edge of the balance plate. Earlier, the balance had been adjusted with a paper cup on each of the pans. After the strip to be tested was in position, tiny glass beads were poured slowly into the paper cup on the plate opposite the one on which the bark was resting. Progress upward toward the gage marking 10 degrees was monitored. Loading of the join was halted when it either failed or flexed to the gage stop. In either case, the cups were reversed on the balance and the beads weighed.

Two of the four joins were tested for post-bending tensile strength, then the third joins were tested for bending strength and for post-bending tensile strength. The fourth joins were used to test the adhesives' reversibility in water.

To test reversibility, the join was rubbed with a cotton swab dipped in solvent and allowed to sit about 10 seconds. Then it was tested by placing a finger on each side of the join and putting tension on it. If the bond was reversible in the solvent it usually came apart readily. Some adhesives took 30 to 60 seconds before the solvent bonds failed. Appearance of the bond after application of the solvent was noted.

Results

Results of the experiments are shown in the following tables:

Key to Adhesives

Trade Name	Preparation
A: Magic Mend	as supplied
B: CM Bond M-2	as supplied
C: CM Bond M-3	as supplied
D: CM Bond M-4	as supplied
E: CM Bond W-2	as supplied
F: Elmer's Glue-All	as supplied
G: AYAF	20% in acetone (w/w)
H: AYAT	20% in acetone (w/w)
I: Duco Cement	as supplied
J: Scotch SuperStrength	as supplied
K: Clapp "Secondary Paste"	as in the reference, except "Golden Harvest" wallpaper paste used for wheat paste portion

Tensile Strength (Before Bonding) Kilograms per Square Millimeter

Sample	Join 1	Join 2	Join 3	Average
A1	.07	.13	.19	.13
B1	.11	.13	.14	.12
C1	.24	.59	.13	.32
D1	.76	.53	.21	.50
E1	.86	.66	.32	.61
F1	.81	.66	.32	.60
G1	.09	FIH	FIH	.04
H1	.12	.37	.04	.18
I1	.16	.04	FIH	.07
J1	.67	.27	.25	.40
K1	.05	FIH	FIH	.02

FIH: failed in handling

Bending Strength
Grams to Failure* per Square Millimeter

Sample	Join 1	Join 2	Join 3	Average
A2	3.69	2.65	2.19	2.84
B2	4.90	7.57	.43**	4.30
C2	5.74	6.56**	5.82	6.04
D2	5.29	4.09	3.26	4.20
E2	3.03	1.85	1.66	2.16
F2	4.31**	12.19**	5.50**	7.33
G2	1.21	1.47	2.27	1.65
H2	2.71**	4.06	1.72	2.83
I2	7.18	2.90	6.26	7.78
J2	3.20	FIH	3.64	2.28
K2	1.16	FIH	3.39	1.52

* bent but unbroken.

** broke and separated

Tensile Strength (After Bending)
Kilograms per Square Millimeter

Sample	Join 1	Join 2	Join 3	Average
A2	.40	.12	.07	.20
B2	.23	.41	.09	.24
C2	.40	BPT	BPT	.13
D2	.44	.74	.37	.52
E2	.41	.40	.50	.44
F2	BPT	BPT	BPT	.00
G2	.03	FIH	.10	.04
H2	BPT	.07	.04	.04
I2	.30	.57	.15	.34
J2	.14	BPT	.30	.15
K2	FIH	FIH	FIH	.00

BPT: broke in previous test

Bending Strength Test
Degrees to Failure*

Sample	Join 1	Join 2	Join 3
A2	7	8	8
B2	9	6	9
C2	7.5	8**	4**
D2	9	8	3
E2	7.5	5	5
F2	3**	6**	7.5**
G2	5	5	8

H2	6**	7	2
I2	9	9	7.5
J2	5	FIH	7
K2	1	FIH	1.5

* bent but unbroken

** broke and separated

N.B. angles by visual estimation

Reversibility

Adhesive	In Acetone?	In Water?
A	yes	no (opaque while damp)
B	yes	no (opaque while damp)
C	yes	no (opaque while damp)
D	yes (quickly)	no (opaque while damp)
E	yes	no (opaque while damp)
F	yes	no (opaque while damp)
G	yes (quickly)	no
H	yes	no
I	yes	no
J	yes (slowly)	no
K	no	yes (quickly)

N.B. solvents applied with cotton swab

Conclusions

All polyvinyl acetate emulsions were easy to work with. All have fast tack and could be manipulated to some extent while setting (e.g. to align join edges exactly). Joins are nearly invisible when dry. Brushes clean with water. CM Bond M-2, M-4 and W-2 have especially good tack.

Polyvinyl acetate resins, Duro Cement and Scotch Super Strength had little tack and required an additional application of the adhesive to one half in order to achieve a bond. The join could not be manipulated while drying without weakening or destruction of the bond. "Good" bonds were those with excess glue on the join, which showed up against the cedar bark as a shiny band. Brush clean up with acetone was slightly inconvenient as the acetone had to be constantly renewed due to evaporation. Rapid evaporation of solvent also made it impossible to work with the brush from small "puddled" amounts of adhesive; the Duro and Scotch SuperStrength cements had to be applied from the tube to the brush and then to the join.

Clapp "Secondary Paste" was found to be difficult to work with. It had almost no tack, even when left undiluted. Best results were achieved when the join halves were pressed together, held very still for about half a minute, then set down very carefully and left to dry undisturbed. No manipulation of the join while drying was possible without failure of the bond. The dried join had good appearance. The brush cleaned up easily with water.

None of the adhesives proved stronger than cedar bark. Some proved less flexible than others but in preliminary tests all but the "Secondary Paste" bent to a 5-degree angle without observable failure. This is equivalent to about 1cm deflection over a 10cm distance, a normal degree of movement in careful basket handling.

Of all the adhesives, the polyvinyl acetate emulsions (Magic Mend, CM Bond M-2, M-4 and W-2) had the best characteristics for basketry repair. M-3 proved to be too brittle. Elmer's Glue-All looks good in strength but lacks the flexibility of CM Bonds (except M-3). This rigidity and strength would be desirable for repair of some types of baskets. However, Elmer's Glue-All is reputed to become effectively irreversible on aging.

Clapp "Secondary Paste" is a disappointment. Many of the glued samples did not make it to testing, despite minimal and careful handling.

Still to be determined are the effects of simulated aging on the test adhesives. Test strips are being subjected to light in the controlled environment of the Fodometer. Following that exposure, the samples will be tested for the same characteristics as described above.

References

- (1) Anne F. Clapp, "Curatorial Care of Works of Art on Paper," Intermuseum Conservation Association, Oberlin, Ohio. 1974.
- (2) CM Bonds and PVA resins supplied by Conservation Materials, Ltd., Sparks, Nevada.
- (3) Data from Conservation Materials, Ltd. catalogue.

81/3/2

REPAIR OF A TLINGIT BASKET USING MOLDED
COTTON FIBERS

Fonda Ghiardi Thomsen

ICOM Committee for Conservation
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Working Group: Ethnographic Materials

REPAIR OF A TLINGIT BASKET USING MOLDED COTTON FIBERS

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Abstract - A small cylindrical Tlingit basket, on exhibit, fell from its mount and was severely broken. Two large pieces were lost. In order to restore the basket's appearance so that it could be returned to exhibit, missing pieces were molded, using cotton fibers, put into the void and inpainted. The basket was structurally strengthened and the aesthetics restored. It was returned to exhibit.

Introduction - The National Park Service maintains a central conservation laboratory for the treatment of the more than five million artifacts under its care. The Tlingit basket was received at the laboratory from the Colter Bay Museum at Grand Teton National Historic Park near Jackson Hole, Wyoming. The basket was on display when damaged. The park wished to return it to exhibit.

History - The basket was part of a collection of Native American artifacts collected by artist David T. Vernon after the turn of the century. Vernon's admiration of the aesthetics of native cultural pieces was the basis for his accumulation of over 2,000 objects from tribes throughout the United States and Canada. Before Vernon's death in 1973, Laurence Rockefeller purchased the collection and donated it to the National Park Service for exhibit in Grand Teton National Historic Park. The collection is on continuous exhibit.

Description - The basket consisted of two parts; a bottom cylinder and a lid. The bottom cylinder measured 8.2 cm high, with a diameter of 10.4 cm. It had straight sides with a slightly concave bottom. There was no decoration on the bottom cylinder. The lid had short straight sides, 1.5 cm high, sloping upward to a center knob with a large flattened mushroom cap appearance, 5.5 cm in diameter. The lid fit over the top lip of the cylinder. Total height, basket and lid, 11 cm. The basket and lid were constructed of twined spruce root fibers. The lid was decorated with dark and light shiny brown fibers in a false embroidery stitch. A zig zag stitch ran around the top perimeter of the lid. The knob had four Greek key patterns around its perimeter.

The environment of the museum was dry, relative humidity of 20%. The basket vibrated off its mount and fell about two meters to the floor. The rim of the lid had separated almost completely. A 3 cm x 1 cm piece, including pattern, was missing from the top perimeter of the lid. The knob was 50% separated from the lid. The bottom cylinder was 80% separated around the bottom 1.5 cm from the edge. A 10 cm circular strip, 1.5 cm wide was completely detached. Four centimeters of the strip were missing. (See figure 1).

Treatment - The breaks in the basket were first mended on the inside using Japanese paper fibers and 2% methylcellulose/1 adhesive. This provided a satisfactory repair to all but the missing areas.

An experimental basket (from the author's private collection) was selected as a test basket. Microcrystalline wax dissolved in Stoddard solvent was applied to the area of the basket selected to make the mold. RTV silicone/2 was applied to the waxed area, allowed to harden, then removed. This made a mold with an excellent negative impression. Two types of fibers were tried for the castings: Japanese paper and 100% cotton fibers. Mediums tried were 2% methylcellulose and 10% pliantex/3. The cotton fibers with pliantex made the most satisfactory casting. The fibers were wetted with medium, tamped into the mold with a stiff brush, allowed to dry, then removed.

Two mold areas were chosen on the Tlingit basket. They were waxed, and the RTV silicone applied. The mold was removed and a casting made with cotton fibers and pliantex, as above.

The cast pieces were put into the voids. They were attached by working the edges into the basket weave with methylcellulose adhesive. (See figure 2).

When firmly fixed into place, the cast areas were painted to match, on the top side only with artists' acrylic polymer medium. Care was taken to not touch the original fibers.

The microcrystalline wax was removed from the mold areas using Stoddard solvent on cotton swabs. (See figure 3).

The basket was returned to exhibit.

Synopsis - The treatment successfully restored the aesthetics of the basket as well as providing increased structural strength. A negative effect of treatment might result from the residues of wax that may remain on the areas where the mold was made. Care must be taken to use minimal amounts of wax and remove as thoroughly as possible. For the author's use at that time, the cotton fibers and pliantex worked. There are a multitude of additional fibers and medium that may work as well or better, depending on what is available, the object, and the skill of the user. This treatment was done in 1974 and a variety of materials are now available that were not at that time.

Supplies

1. Methylcellulose - Talas, 130 Fifth Ave., New York, New York, 10011.
2. RTV - 31 - Red liquid Silicone Rubber - General Electric Silicone Products Department, Waterford, New York, 12188.
3. Pliantex - Frank Joel, L&D, P.O. Box # 6, Downham Market, Norfolk, PE, 389ED.

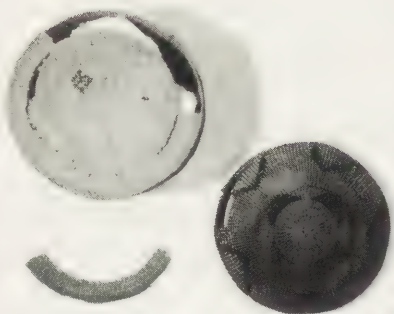


Figure 1. Tlingit basket before treatment.

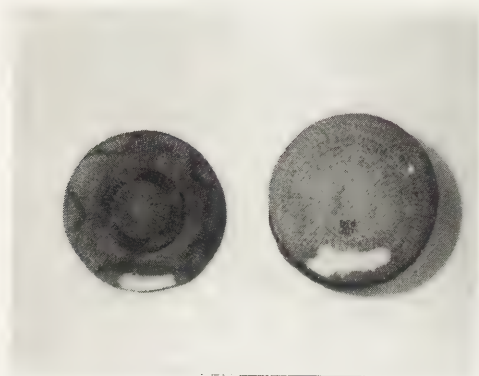


Figure 2. Tlingit basket after repair before inpainting.

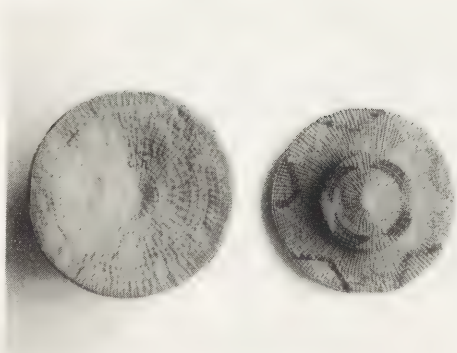
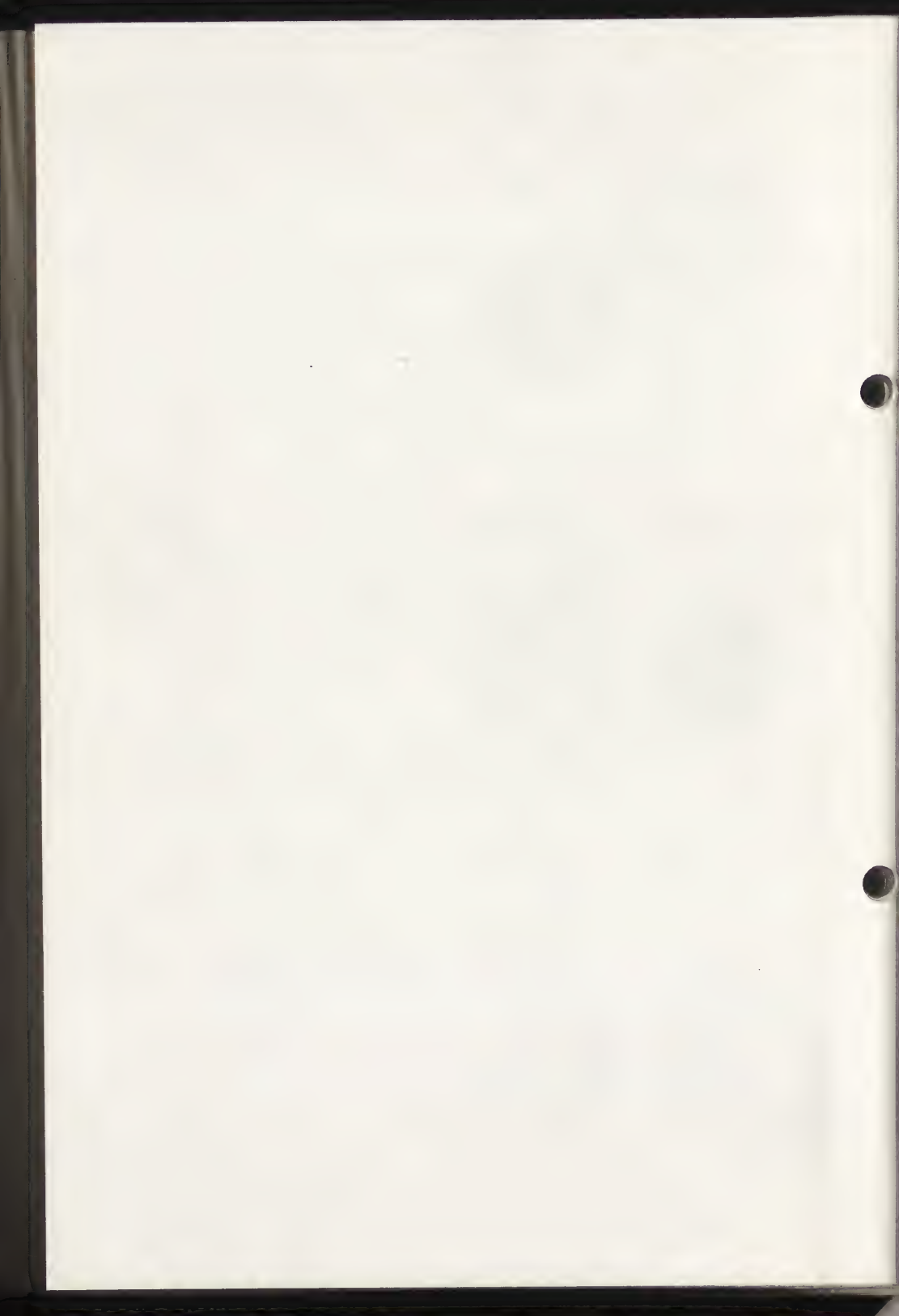


Figure 3. Tlingit basket after treatment.



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THE CONSERVATION OF A HAWAIIAN SLEEPING
TAPA

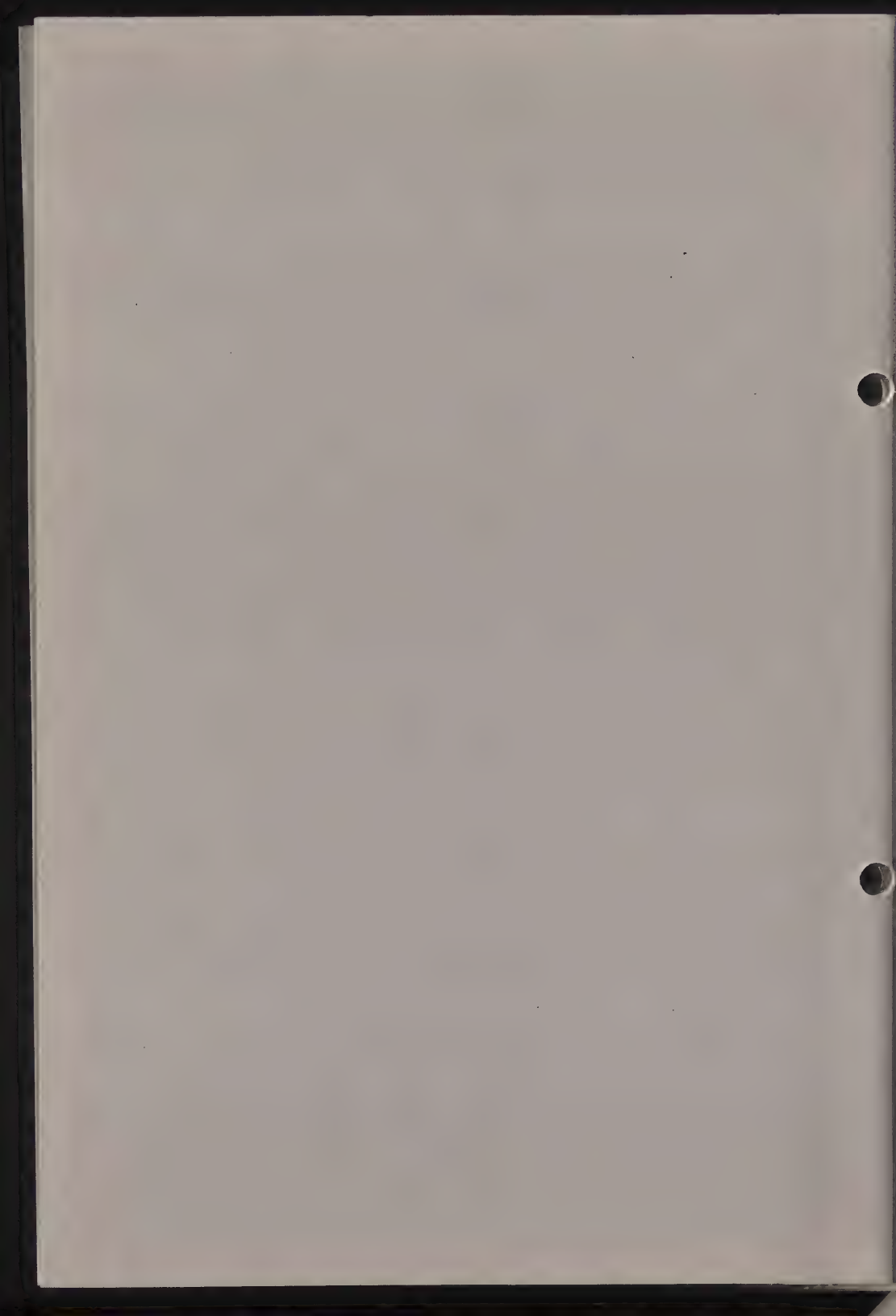
Susan Nash Munro

ICOM Committee for Conservation

6th Triennial Meeting

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Working Group: Ethnographic Materials



THE CONSERVATION OF A HAWAIIAN SLEEPING TAPA

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The repair of Polynesian bark cloth in a sense straddles two different conservation disciplines--textiles and paper. The materials and method of manufacture will be familiar to paper conservators; the decoration and use of tapa will be familiar to textile conservators.

A complete discussion of Hawaiian tapa making and usage would not be practical here, nor is the author qualified to undertake such a task. The background information supplied is obtained from the Bishop Museum publication "Tapa in Polynesia," by Simon Kooijman, 1972.

The term "tapa" in reference to articles made from bark cloth in the Pacific became widespread in the early part of the 19th century by European and American traders. The Hawaiian variant of this general term is "kapa." It was used largely as a textile to be worn, slept under or hung. Its manufacture in Hawaii reached a high art. It could be made tissue-thin, fine, white and soft, or decorated in intricate patterns and delicately colored. It was, unfortunately, rapidly superseded by woven textiles and doesn't seem to have been made much after the mid-19th century.

The raw material is usually the bast fiber of the *Broussonetia papyrifera* known to all paper conservators as the paper mulberry tree. This plant is not native to the Hawaiian islands and was introduced by the early Polynesian emigrants. It was cultivated by the Hawaiians on plantations and vast quantities of kapa were made by the women. Lesser quality kapa was made from the breadfruit and fig trees, but also less often.

The long, thin stalks of the mulberry tree were harvested when from

six to twelve feet high. The bark was peeled off and stored in folded bundles. Then shell scrapers were used to remove the outer bark. The inner bark was alternately soaked in sea water, fermented, and beaten until it was a pulpy mass. The fibers, just as with Oriental paper, remained extremely long.

The beating of the fibers into a thin sheet took place with hardwood clubs over an anvil, first of stone, then of wood. Coarsely grooved sides of the club would be used first, then gradually finer grooves until smooth sides. A final impression, or watermark, would complete the sheet. This watermark is generally some geometrical design, but the exact method of application is uncertain. Then the sheets would be weighted with stones along the edges and dried. As the kapa shrank, the stones had to be carefully moved to prevent tearing.

Coloring and decoration were done in a wide variety of ways. The fibers themselves could be dyed, then beaten into sheets. Or different colored sheets could be beaten onto the surface of a white sheet. Free-hand painting, stenciling and stamping with carved bamboo stampers might complete a kapa. Dyes were vegetable, mineral, or carbon.

The kapa in question is a very good, typical example of a kapa moe, or sleeping tapa. Five sheets of kapa are sewn together at the top and layers can be ~~ht~~rown back or brought up, depending whether the night is warm or cool. The top layer, or kilohana, is the only decorated layer. The others are white. The method of attachment is interesting as the stitching is done with twisted tapa cord and the layers are folded in such a way as to hide the stitching. The sheets were between 251 and 258 cm. wide and 207 cm. long. All five sheets had a watermark of the "upena halua pupu" type, diamonds with a dot in the middle. The diamond shapes were approximately 1 x .8 cm.

The kilohana layer is red on the top side, white on the reverse. Microscopic

examination revealed that the red fibers were completely dyed and may have been a piece of red cloth pulverized to form the top layer. There were small woven fragments throughout the surface. The designs were of a blue dye and may have been stenciled on. However, similar patterns are not especially uniform so there may have been some freehand painting involved.

The kapa had been hung at one time, but had been stored for many years folded up. It was very dusty and throughout the layers, but especially in the folded stitching, were remains of dead flies and the ubiquitous cockroach. These had made black stains. The kilohana layer was covered with small brown spots, probably fly specks. The specks were eating through the kapa.

The kapa may have been turning slightly brown with age. Layer five was certainly browner on the side exposed to light than any of the interior sheets. There were no obvious areas of fading on the dyed designs.

On layer one along the left edge there were extensive tears extending 53 cm. into the center. The upper right edge has a small tear. Layers one, two, and three have a hole, center right, 46 cm. in from the edge. On layer five, looking at the reverse side, lower left edge, is a tear extending 36 cm. in.

There were many creases and wrinkles where the kapa had been folded. Many edges had been turned and were creased.

The initial step in treatment was to vacuum all surfaces of the dust and insect bodies. The next problem was to relax each layer, flatten the edges and remove the wrinkles. The technique used was similar to the original drying technique. The kapa was put under tension by weights along each edge and then it was sprayed with moisture. The fibers respond wonderfully to moisture and the pieces dried remarkably well. The sheets were not, however, "flat," and probably never were.

The mending of tears was done just as any paper conservator would--using

mulberry paper patches and paste, in this case methyl cellulose, but starch paste would be fine. The tears mended invisibly. The hole in the first sheet was filled with mulberry paper.

Because the owner intended to hang the kapa moe in a hallway where it would be affected by breezes, it was decided to reinforce the kilohana layer, which was quite badly torn. A previous experience brought me to this decision, though I would have preferred, and still prefer not to back objects whenever possible. In this previous experience, a much torn up and very large piece of Samoan tapa was patched in the same way, but not reinforced with a backing. When it was hung in a stairway and the outside doors were opened, the incoming breezes tore it apart again.

A traditional paper conservator's backing of large pieces of mulberry paper seemed out of the question here. The five sheets would have had to be dismantled, thus disrupting the stitching technique at the bottom. The sheets seemed enormous, ever more enormous when considering the logistics of applying large pieces of wet mulberry paper to its verso. The drying rates would have been different between the kapa and the paper. And it would, I believe, be difficult to remove such a backing since the materials are very compatible, very similar in nature, and their presence might be a source of confusion to, say, a future researcher. This complaint was voiced to me by a curator who had encountered old repairs in native materials, but had no way of knowing whether these had been done in the museum or by the cultural group which had produced the object. Museum records are very faulty on this score.

The materials chosen have also their own drawbacks. The stability of the resin has been called into question, as well as the ease of reversibility. On the other hand, the backing could be applied without introducing moisture and drying problems, and the materials are completely synthetic and could not be confused with traditional use. The kilohana layer was therefore lined with

nylon laminating tissue and a heat-set polyamide resin, as sold by Process Materials Corp. in the U.S. This is soluble in methanol, less easily in ethanol, and was applied so as to adhere to the very top fibers. It can be pulled off with the minimal use of solvents. The backing was ironed on in four sections and extends up to the stitching at the top.

There was a black deposit on the last sheet of tapa which was soluble in dimethylformamide. As much as possible was removed without weakening the tapa. It did not appear to be mold, but the area was brushed with laurel pentachlorophenate (4% solution in mineral spirits) as a precaution. The insert was toned with watercolors to make it blend in appearance.

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A REPORT ON THE TREATMENT OF BARKCLOTH

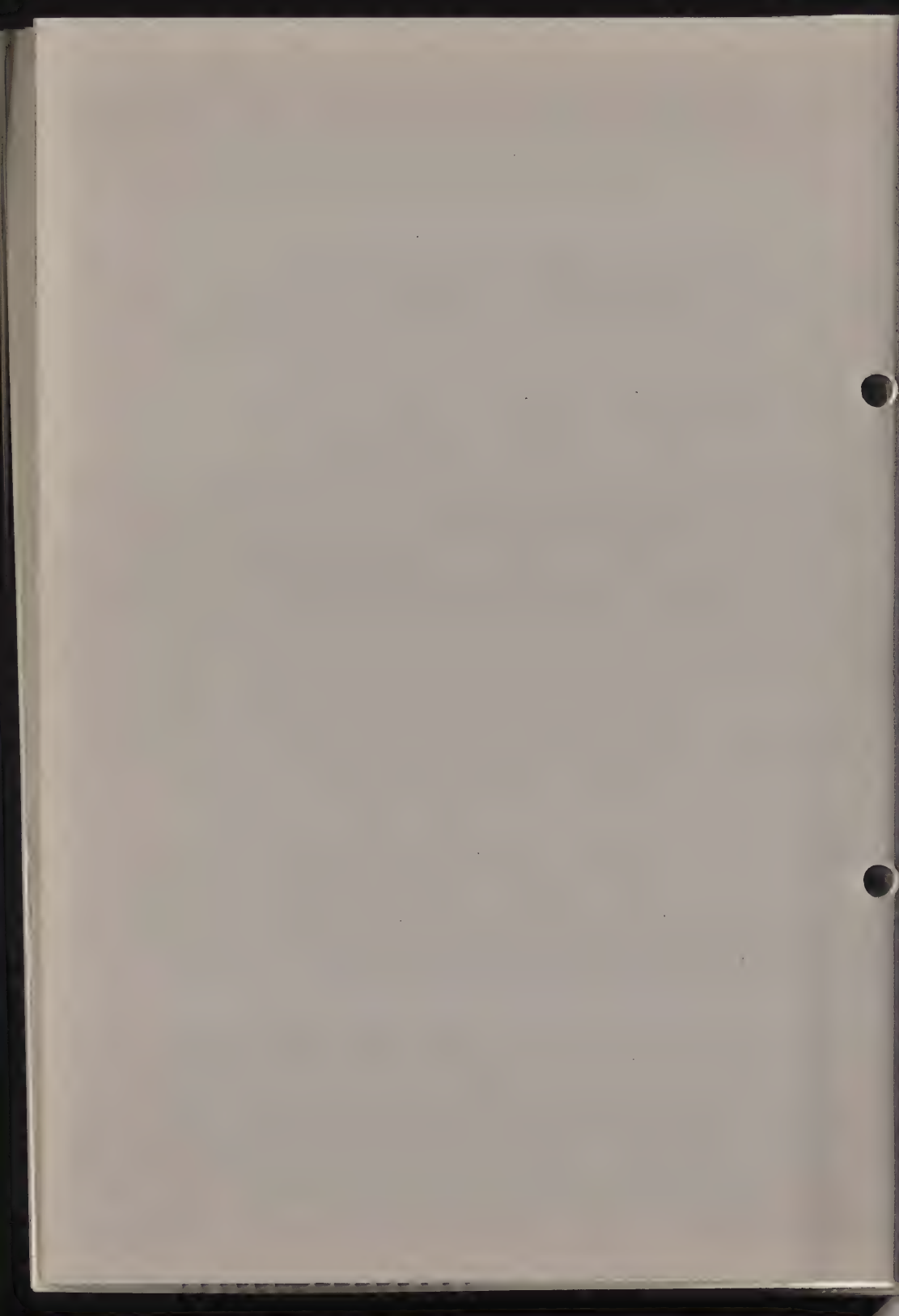
Arne Bakken and Kirsten Aarmo

ICOM Committee for Conservation

6th Triennial Meeting

Ottawa 1981

Working Group: Ethnographic Materials



A REPORT ON THE TREATMENT OF BARKCLOTH

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Abstract

This report describes the cleaning of bark cloth and the treatment with polyethylenglycol and natriumcitrate as conservation agent and buffer against acidity. Method for repair is also described.

The Ethnographic Museum in Oslo delivered a report to the ICOM meeting in Zagreb on the conservation of objects made of plant material (no. 78/3/2). This work was encouraged by the working group on ethnographic material at the ICOM meeting in Venice 1975.

The report describes the use of Polyethylenglycol 400 as a medium to restore flexibility to fibers and to strengthen the material. The first objects were treated in 1972 and they have been kept under close control these past nine years. The treatment seems successful with regard to flexibility and strength and as yet we have not seen any harmful effects. It must be added that since 1976 the material has been kept in a stable climate at 20°C and 55% RH.

After four years' interruption due to the rebuilding of our museum, we resumed our work in 1978. This time we started work on the plant material tapa or barkcloth on the recommendation of the ICOM working group 3, ethnographic material.

We read Erika Schaffer's article in Studies in Conservation, no. 3/1976 about the use of PEG on objects made of cedar bark. Her experiences encouraged us to continue along the lines which were drawn up by our own work from 1972 to 1974.

We will start with a few remarks about the material itself. Barkcloth is a product of tropical countries, and its manufacture encircles the globe. It is made in Africa, the Malay peninsula, Indonesia, New Guinea, Melanesia, Polynesia and in South America. Each place has a lot of names for the product, due to the many different qualities, but we shall use the common European name, tapa. This name will be used to describe the paper-like product made from the beaten inner bark of various trees or bushes. The inner bark, or the bast, is separated from the bark by various methods and beaten to desired flatness by means of special beaters. The strips of beaten bast are then glued together into a sheet of desired size. To obtain the necessary thickness, different types of glue are used to stick several layers of tapa together. Some material has sufficient natural sap and does not need an addition of extra glue.

Although the tapa has many similarities with paper, it differs greatly in one aspect. Paper is made from desintegrated fibers, but the fibers in the tapa are always kept in their original structure.

Now, before we go on to describe the actual conservation process, we will say something about the discussion we had before we started. Many of the tapas in our museum are in a very grimy state due to the dust collection on the surface. It is furthermore likely that harmful chemical pollutants from the air are present. It was evident that washing of the tapas would be desirable to remove the grime and the watersoluble chemical pollutants. But since the tapa contains natural glue and in many cases vegetable glue had been added, we feared that this would dissolve and disappear in the washing process. If this should happen, we would want to replace the loss of original glue. Furthermore we wanted to strengthen the fibers and to make the material more pliable. We also found that deacidification was necessary.

To make some tests we cut off a bit from an uncoloured, undecorated piece of tapa in our collection. One small square was cut off the trial piece to show the untreated material. The rest of it was placed in a bath of luke warm water with 5% (by volume) Lissapol N for half an hour. The water had then turned grey and the PH value was 4. The tapa was now rinsed and placed in a new bath like the first. After another half hour a soft sponge was used gently to squeeze the water through the tapa. It was then rinsed six times, the last time in distilled water, and then dried. Once again a small square was cut off to show the washed tapa. The rest of the test piece was cut in small squares which were treated in different ways. We shall not go into details here, but come to our conclusions of the tests:

1. The washing process seems safe provided that the tapa is handled with great care while wet.

2. Addition of CMC (carboxymethylcellulose) glue makes the tapa less flexible and it does not seem necessary because the loss of natural glue is not noticeable.

3. Addition of 10% (by volume) of PEG 400 makes the tapa more flexible, but a lower concentration is recommendable because it makes the tapa slightly greasy.

4. And finally we found that the best chemical agent as a buffer against acidity was natriumcitrate which could be dissolved in the same solution water as the PEG. Both could then be applied together. Two of the small test pieces showed a PH value of respectively 7,7 and 6,3 after the buffer treatment.

We now felt that we had reached a point where we could start on the decorated tapas, and we shall therefore go on to describe the conservation of one of them.

The size of it was 108 by 42 cm. and it seemed to be cut off from a larger piece. It was very thin in the structure and decorated with a blackish brown colour. A lighter brown had been used to draw some guidelines before the pattern was filled in with the blackish brown colour. It was difficult to decide whether the pattern was painted or printed on - or whether it was a combination of both.

The tapa was damaged by some smaller and larger holes, and there was a tendency to cleavage between the layers in several places. There were folding marks across the pattern and in the creases the colour of the decor had fallen off. The colour was also missing in a patch where it seemed as though the colour had been etched away. The material itself was also missing in the middle of the patch.

The tapa was not very grimy.

All the colours were tested for fastness, and the torn and ragged parts of the tapa were covered with gauze on both sides. The gauze was stitched on before the tapa was placed on a sheet of perspex. It was then placed in a bath of luke warm filtered water with 1,5% (by volume) Lessapol N. After one hour it was gently pressed with the palm of the hands to increase the washing effect. The tapa was now taken out of the bath and the PH value of the water was measured with Lyphan paper, which showed a value of 4. The perspex sheet with the tapa was raised to a sloping position against the edge of the basin and then covered with a fine nylon net for protection while it was rinsed with a hand shower. The last part of the rinsing was done with distilled water. The surplus water was drained off with blotting paper. Another perspex sheet was

then placed on top and the whole thing was turned over. The first perspex sheet was now removed and more water was drained off from the reverse side.

As a buffer against acidity we used 0,5% natriumcitrate in a 6% solution of PEG 400 in distilled water. This was richly dabbed on the reverse side. After one hour the surplus liquid was removed. The tapa was again turned on to its right side and the fibers around the holes were laid in order while still wet. To dry out we used blotting paper and a sheet of perspex as a light pressure.

The next day it was dry and we could begin the restoration. As material for the repairs we chose thin Japanese paper slightly coloured to suit the ground material in the tapa. As glue we used CMC glue in a concentration of 0,29% (by weight) in distilled water. The CMC is regarded as a safe glue in paper conservation. The glue was sparingly applied with a brush to the reverse side around the torn places and the Japanese paper pressed on with a gauze compress. A piece of acid-free tissue-paper was placed on top with blotting paper as cover. The tapa was then turned over and the front of the repair was also covered with tissue-paper and blottingpaper under a glass-plate with a small weight as pressure on top. The tissue-paper was changed a couple of times to avoid that it should stick to the glue. The whole thing was now left to dry until the next day.

After this treatment we found that the tapa was flat and soft. The tendency to cleavage between the layers was no longer apparent and the holes were less noticeable because the ragged edges were straightened out. The missing parts of the decoration were not filled with new colour. The PH value of the treated tapa was measured to 5. The reason for this low value is not apparent to us. We had hoped to get a value nearer 7 as in the trial pieces.

In another decorated tapa we have made some tests to try and fix flaking paint. The decor consists often of a thick shiny and opaque layer. This hard, nonflexible layer harmonizes poorly with the porous structure of the tapa itself, so it has a tendency to flake off. To solve this problem will be our next task. We hope to put forward a report on this problem at the next ICOM meeting in 1984. It must be added that the treated tapas are small. The problem of treating very large tapas must be paid attention to.

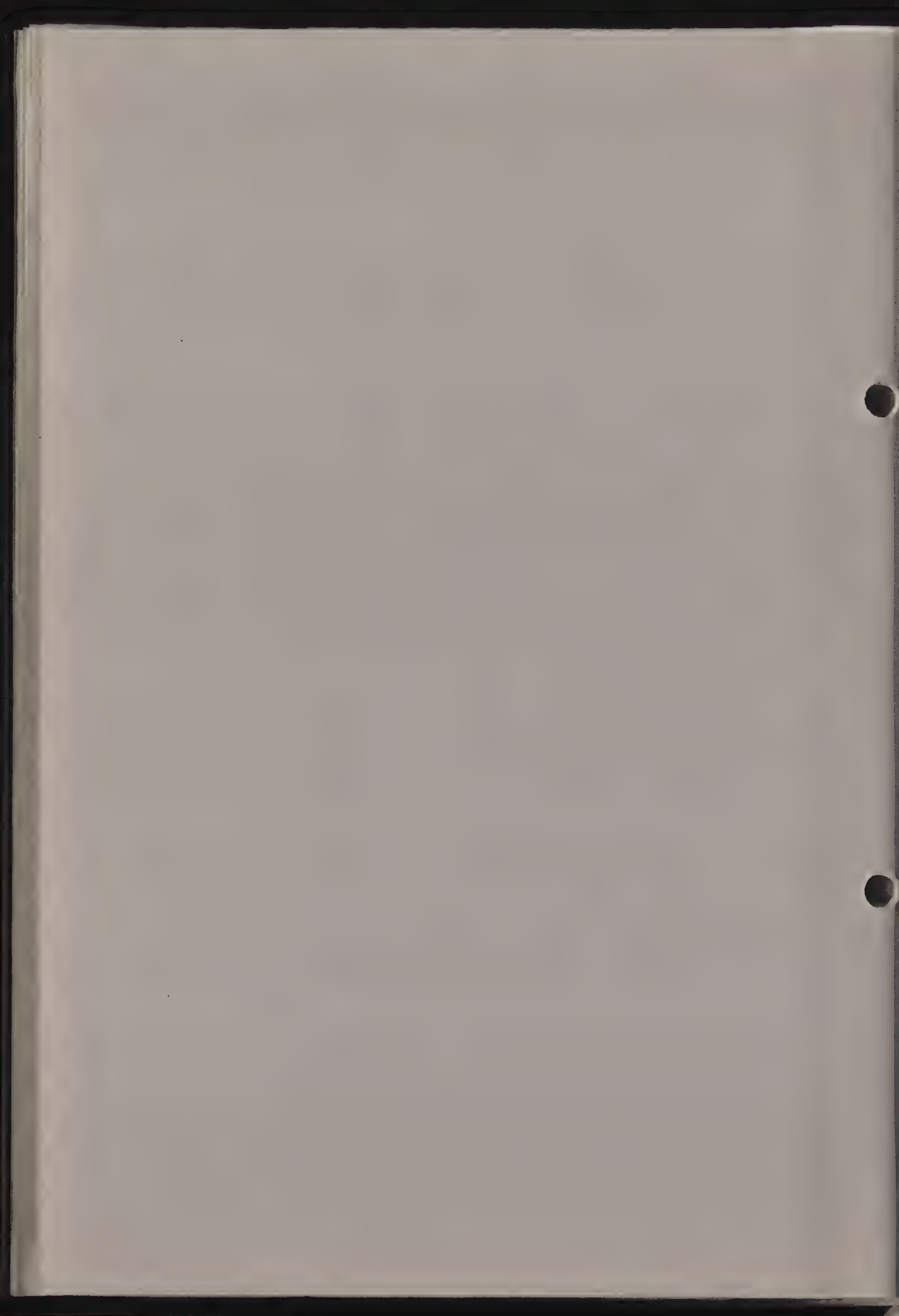
81/3/5

ADHESIVES USED IN THE BRITISH COLUMBIA
PROVINCIAL MUSEUM CONSERVATION LAB

Richard Renshaw-Beauchamp

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Ethnographic Materials



ADHESIVES USED IN THE BRITISH COLUMBIA PROVINCIAL MUSEUM
CONSERVATION LAB

Richard Renshaw-Beauchamp

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Three years ago when we were all in Zagreb I said I was willing to give a short paper here in Ottawa on the subject of adhesives. I think it is a good sign that since that time the philosophy of the laboratory, of the people in the laboratory, has developed and changed so that now we are a group actively engaged in Preventative Conservation who only treat objects when their integrity is threatened by some weakness or when they are so dirty, stained or obscured that they cannot be studied properly without removal of the accretions. When we must use adhesives we use the following:

Starch Paste; the regular as per Anne Clapp:

wheat starch 30 gm
distilled or filtered water 200 ml
thymol solution in alcohol (ethanol or
denatured ethanol) 9-10 drops

For the method of preparation see "Curatorial Care of Works of Art on Paper", 3rd edition, July 1979 by Anne Clapp published by Intermuseum Conservation Assoc., Oberlin, Ohio. This is an excellent, stable paste - strong, white and with a good tack. It has, as Ms. Clapp says, been tested through hundreds of years and not found wanting. It is completely reversible. If a more flexible adhesive is needed, for mending basketry for instance, then a proportion of methyl cellulose paste should be added. The methyl cellulose powder is mixed in cold water as directed and incorporated thoroughly into the starch paste as and when needed (never more than 40% to 60% of starch paste).

Where a starch paste would be incompatible and a quick drying adhesive, reversible in an organic solvent, is needed then we use a straight cellulose nitrate in acetone which can be bought commercially under many trade names. We use "H.M.G.". This adhesive remains permanently soluble in acetone.

Where more strength is needed in a join, especially when the mend must support either itself or even more weight, and in

the repair of leather we use Jade 403. This is an internally plasticized polyvinyl acetate emulsion that contains no solvents. It is only used when Starch Paste or H.M.G. will not do, as its reversibility is suspect after an extended period of time.

For mending glass we use Epo-Tek 301 low viscosity epoxy. This adhesive has a refractive index very near to that of glass. We usually "spot weld" broken pieces together with "Crazy Glue" then run in the Epo-Tek while warming the piece with an infra-red lamp.

This is a very restricted repertoire of adhesives but Helmut Ruhemann's advice about solvents is also applicable in this field, "restrict the number you use but become very proficient in their use". There are hundreds of adhesives on the market, but providing you choose one of known and proven reversibility - not just reversible in theory - and get to know it well, you will be all right. There is one bit of advice I would like to give though, and that is don't use a glue that will give you a joint stronger than the materials being joined. Should the object, after mending, start to move, it will break along the old mend instead of opening up a new split or break. You are thus helping to protect the integrity of the object.

To revert to my opening remarks, artifact conservation has come a very long way from its humble beginnings when under-paid and overworked craftsmen, relegated to a dim basement, sawed, glued and hammered away at the evidence of our past. It was the paintings "Restorers" who first became respectable, becoming "Conservators" and joining forces with the scientists to better understand materials and causes of degradation. It was not until much later that objects conservators achieved such respectability and it was really only possible because of the "Paintings People".

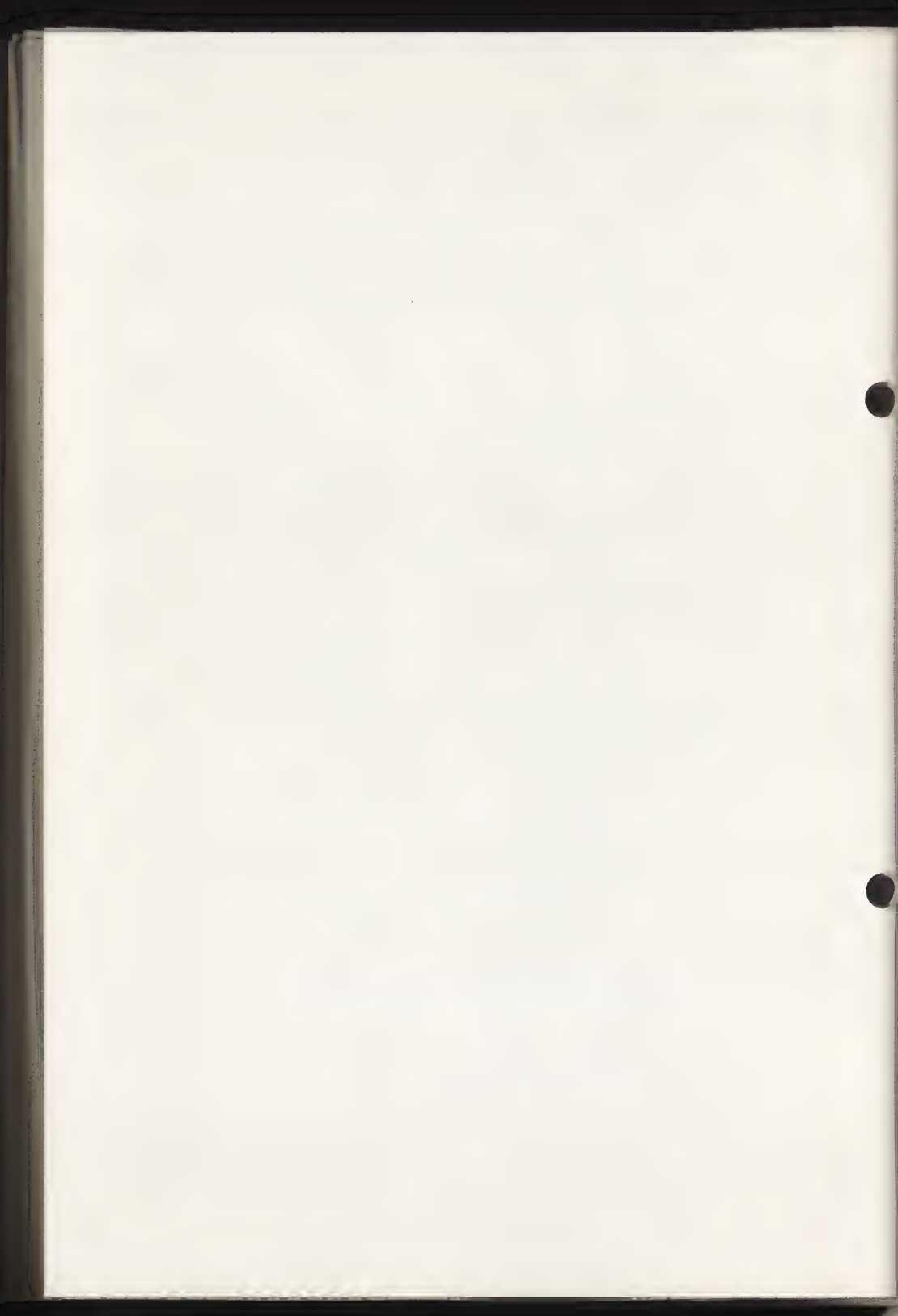
It is no wonder therefore that the ethics of both groups in the treatment of artifacts were and, to a large extent, are the same. I don't think that this should be so. Historic and ethnographic artifacts are the only real hard evidence we have of our past. We cannot afford to alter them for the sake of aesthetics and thus falsify the facts. There are, I know, a number of curators who only use their collections to illustrate their theories and who consider the artifacts in their care as window dressing or display props. Luckily, they are a small minority. Conservation must work patiently with them and try to convince them otherwise.

The less we treat our artifacts the truer the evidence which can be obtained from them will be. The only way we can ensure that this course of action is possible is by practicing preventative conservation. We must worry about light levels and convince curators to join with us in making exhibit designers plan for less light. Museum administrators must realize that they are guilty of neglect if they will not insist on environmental

controls to protect our heritage which has been bought with our money and placed under their protection. We, the conservators, are the people who must lead the push to reduce the need for conservation treatment. It is we who must persuade the universities to include more "Conservation for curators" in their museology courses. Once curators truly curate with a well-founded background of knowledge in preventative conservation then we can go back to being less militant and concentrate on trying to improve upon what we consider today to be perfect environmental conditions.

The true role of institutes of Conservation not attached to a museum is perhaps the provision of research and development facilities and esoteric very highly specialised expertise which would be available "on loan".

The work-a-day conservators employed in such an institution perforce have become treatment oriented because in such a situation there is no real contact with the artifact when it is in storage or on exhibit nor is there daily contact with those who curate the artifact. When this happens there is a tendency for the treatment to become more important than the artifact. This was very obvious to anyone observing the IIC-CG meeting of 1980 and is apparent in many papers presented to the AIC. Erudition is all well and good but it should not be an end in itself. Our working lives should be dedicated to the preservation of the artifact and if along the way we feel we should share our knowledge or our feelings with others then let us write papers. We should not look upon the collections we care for as stepping stones in our career path.



LES TOILES PEINTES FIXEES SUR VERRE DES
BOUTIQUES PARISIENNES: DEGRADATION ET
RESTAURATION

Marie-Odile Kleitz et Philippe Langot

Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981

Groupe de travail: Matériaux ethnographiques

LES TOILES PEINTES FIXEES SUR VERRE DES BOUTIQUES PARISIENNES : DEGRADATION ET RESTAURATION

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Résumé : Une technique particulière se répand au XIXème siècle dans la décoration des plafonds et des vitrines de boutiques parisiennes : une toile peinte est fixée sur un verre au moyen d'une gomme soluble à l'eau.

La restauration de ces panneaux nécessite la séparation de la toile et du verre. Or sous la couche picturale, la toile a souvent été enduite d'un apprêt à la colle. Comment agir sur la gomme qui assure l'adhésion sur le verre de la toile peinte, sans endommager la préparation ?

Le Laboratoire de Restauration et Conservation du Musée National des Arts et Traditions Populaires a mis au point une méthode d'intervention :

- Plusieurs couches de paraloid B 72 diluées progressivement de 5 à 20 % dans le trichlor éthane sont passées sur l'envers de la toile ; ce qui a comme double fonction, de renforcer l'adhésion de la préparation sur la toile puis de rendre celle-ci imperméable à l'eau.

- Le panneau est ensuite placé en atmosphère saturée de vapeur d'eau à température ambiante. Le verre peut ensuite glisser sur la toile sans dommage pour la couche picturale.

- Après restauration, la toile peinte est refixée sur le verre en utilisant les mêmes adhésifs que ceux employés au XIXème à cause de leur grande réversibilité.

Le milieu du XIXème siècle voit à Paris un immense essor de la peinture décorative qui se répand dans les magasins de toute nature et particulièrement dans les magasins d'alimentation. Ces vitrines, ces plafonds décorés qui étalent aux yeux de tous l'opulence du commerçant doivent néanmoins résister aux intempéries, aux fumées des chauffages et éclairages, aux vapeurs grasses. C'est ainsi que se développe en se transformant une technique jusqu'alors limitée à certaines miniatures : la peinture la plus souvent sur toile est fixée sur un verre qui

assure une protection plus efficace qu'un simple verni.

Une centaine d'années plus tard, le Musée National des Arts et Traditions Populaires qui a collecté une partie de ces décors, se trouve confronté à un problème nouveau de restauration : lorsqu'un verre très cassé, ou une toile très endommagée nécessite pour la restauration du panneau la séparation de la toile et du verre, par quelle méthode effectuer cette intervention sans dommage pour la couche picturale ?

Pour mettre au point cette méthode nous avons dans un premier temps fait l'inventaire des différentes techniques de fabrication de ces peintures fixées sous verre, à partir des journaux professionnels du XIXème siècle, des correspondances privées de certains artistes décorateurs.

Nous avons ensuite procédé à l'analyse des matériaux dans le cas précis du problème que nous avions à traiter.

Puis nous avons constitué des échantillons sur lesquels nous avons appliqué différentes méthodes d'intervention.

I - Techniques de fabrication des "Toiles peintes fixées sous verre".

1.1/ Le support. Initialement en taffetas pour les miniatures dont dérivent les vitrines et les plafonds peints, le support est vite devenu pour des raisons économiques, une simple toile de coton, voire un caliquot (toile très fine) et même du carton, ou du papier.

Pour des raisons de durabilité, la toile a pu être remplacée par une feuille d'étain (qui adhérerait mieux au verre) ou plus tard par de la moleskine (toile enduite de matière plastique).

1.2/ La préparation appliquée sur le support est généralement un enduit lié à la colle de peau.

1.3/ La couche picturale est à base de pigments minéraux broyés, liés à l'huile.

1.4/ La toile peinte, séchée puis dégraissée à l'alcool est enduite d'une épaisse couche de gomme, mélange en proportions variables selon les ateliers, de gomme arabique blanche, de sirop de sucre candi et de fiel de boeuf, puis elle est soigneusement appliquée sur un verre.

2 - Les dégradations subies par ces toiles fixées sous verre

Soumis pendant une centaine d'années à des variations climatiques importantes, (voire même aux intempéries) à des agressions de fumées et de vapeurs grasses, ces panneaux nous arrivent quelquefois dans un état de dégradation considérable. Les verres ont souvent été cassés. Parfois la cassure est nette mais il n'est pas rare qu'un choc ait provoqué un faisceau de cassures défigurant complètement l'objet. Le verre cassé ouvre

une voie par laquelle peut s'infiltrer d'autres agents de dégradation tels que l'humidité ou les vapeurs grasses, et peut également couper la toile ou la couche picturale principalement au cours des différentes manipulations.

La colle, à base de gomme arabique, fixant la toile sur le verre a jauni sous l'effet de la lumière solaire ou de l'éclairage artificiel. Ce jaunissement rend parfois le décor illisible. Sous l'effet d'une humidité excessive l'adhésif a pu se dissoudre provoquant la séparation de la toile et du verre.

Quelquefois sous l'effet d'une chaleur trop intense ou d'un climat trop sec la gomme s'est déshydratée à l'excès et s'est transformée en petits cristaux formant poudre, provoquant par là également un défaut d'adhésion de la toile sur le verre.

Lorsqu'elle n'est plus adhérente au verre, la couche picturale, qui n'a pas été protégée par un verni, est extrêmement sensible aux variations d'humidité, rapidement, elle s'écaille, devient pulvérulente et se détache du support. La préparation lorsqu'elle a été soumise au travers de la toile à des atmosphères trop humides se détache de celle-ci.

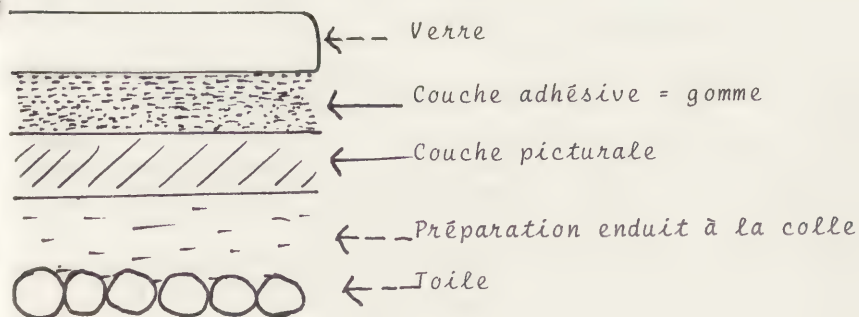
Le support soumis aux vapeurs grasses, aux poussières, à l'humidité, qu'il soit de toile, de carton, de métal, est parfois lui-même dans un état de dégradation avancé.

3 - La méthode d'intervention

Le Laboratoire de Restauration et de Conservation du Musée National des Arts et Traditions populaires n'a eu à traiter que des toiles peintes fixées sur verre.

L'analyse au microscope d'une coupe transversale de peinture selon la méthode mise au point par Mme MARTIN au Laboratoire de Recherche des Musées Nationaux a mis en évidence une préparation à base de colle protéinique, des liants huileux pour la couche picturale, un adhésif à base de gomme pour l'adhésion de la toile sur le verre.

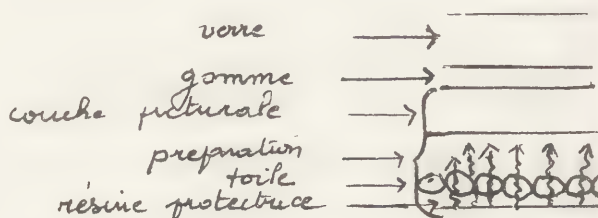
Figure 1 : coupe transversale du panneau



Dans certains cas (verre cassé en étoile, couche picturale fortement endommagée par suite de sa perte d'adhésion au verre), toute l'opération de restauration exige comme phase préalable la séparation de la toile et du verre. Le problème qui se pose alors est de dissoudre la gomme, adhésif entre la toile peinte et le verre, sans endommager la préparation à base de colle de peau (la colle et la gomme étant l'une et l'autre également solubles dans l'eau).

Le seul solvant utilisable pour ramollir la gomme est l'eau. Pour la faire pénétrer entre le verre et la peinture, nous avons pensé l'utiliser non pas à l'état liquide, mais à l'état de vapeur dans une atmosphère saturée, à température ambiante, ce qui permettait une action plus régulière et plus douce. Pour empêcher cette vapeur d'eau d'agir au niveau de la préparation, il faut "imperméabiliser" l'ensemble préparation/toile.

Fig 2.



On voit sur la fig. 2, que l'action de la vapeur d'eau se fera alors exclusivement sur la gomme.

Les opérations se déroulent ainsi :

- 1°) La toile est nettoyée avec une brosse sèche puis dégraissée sous hotte au trichlorotrifluoroéthane.
- 2°) Une première couche de paraloïd 872 à 5 % dans le trichloroéthane est passé sur l'envers de la toile. Pénétrant à travers celle-ci à l'intérieur de la préparation, il renforce l'adhésion préparation/toile.
- 3°) Les couches suivantes à 10, 15 et 20 % assurent une barrière à l'infiltration de la vapeur d'eau à travers la toile.
- 4°) Le panneau est placé à plat dans un humidificateur (boîte en verre étanche) contenant de l'eau additionnée de fongicide (orthophénylphénol) qui empêche le développement des moisissures, le panneau restant plusieurs jours en atmosphère humide.
- 5°) Au bout de deux à trois jours, le verre peut glisser sur la

toile sans qu'aucune écaille de peinture ne se détache.

6°) La surface de la toile fortement engluée de gomme est alors nettoyée.

7°) Refixage et retouches sur la couche picturale peuvent être effectués s'il y a lieu.

8°) Nous avons dans un premier temps envisagé de ne pas refixer la toile sur un nouveau verre, mais simplement de l'y appliquer pour ne pas l'exposer à une nouvelle transposition en cas d'accident. Mais l'aspect est lors très différent de celui des panneaux de boutique où la toile est collée. De plus cette différence s'accroît au vieillissement car la toile peinte non protégée par le verre, se craquelle rapidement alors qu'un panneau de boutique qui vieillit dans de bonnes conditions reste parfaitement lisse et exempt de craquelures. Afin de conserver cet aspect particulier, nous avons décidé de refixer la toile sur un verre.

Pour cela nous avons utilisé les techniques des artisans décorateurs du XIX^e, leurs adhésifs étant d'une plus grande réversibilité que les adhésifs synthétiques modernes.

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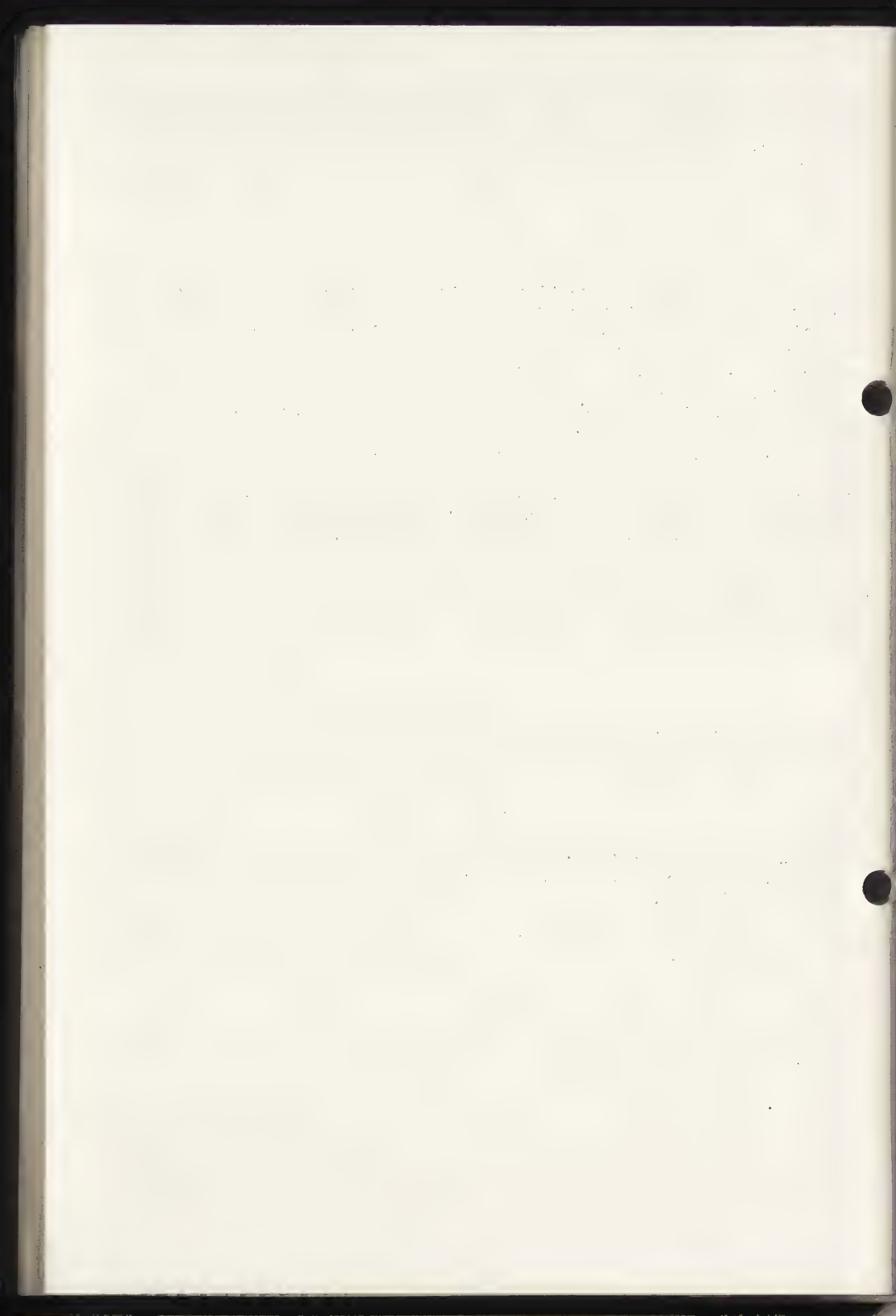
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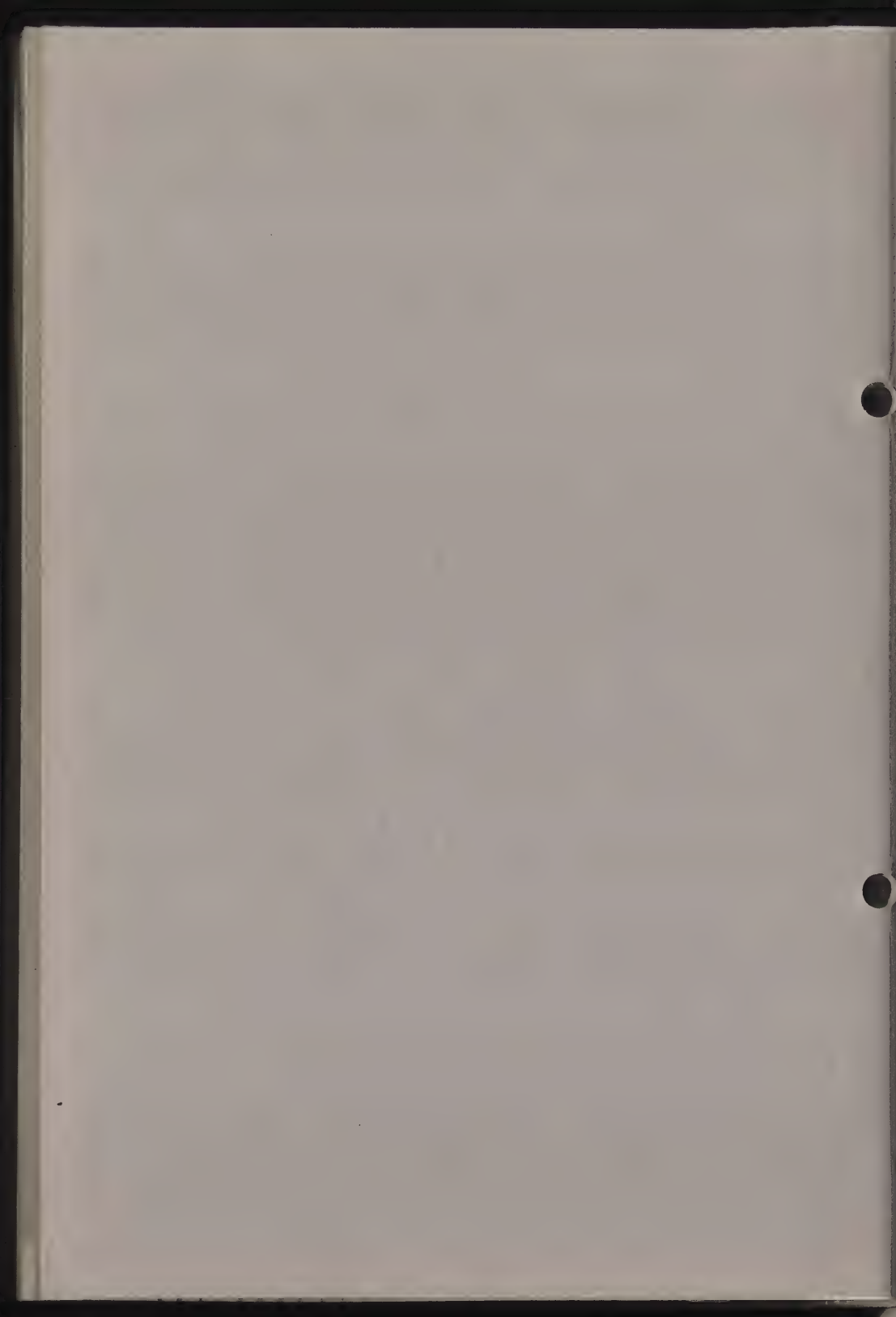
81/3/7

PROTECTION OF MUSEUM EXHIBITS AGAINST
LEATHER-EATING BEETLES (COLEOPTERA,
DERMISTIDAE) WITH THE HELP OF REPELLENTS

G.A.Zaitseva

ICOM Committee for Conservation
6th Triennial Meeting
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Working Group: Ethnographic Materials



PROTECTION OF MUSEUM EXHIBITS AGAINST LEATHER-EATING BEETLES
(COLEOPTERA, DERMISTIDAE) WITH THE HELP OF REPELLENTS

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Leather-eating beetles of *Anthrenus* Shaeff and *Attagenus* Latr. species are harmful pests causing damage to museum exhibits and materials containing keratin.

Larvae of leather beetles greedily eat woolen cloth and silks (among them velvet) as well as objects made of feathers, fur and raw horn. They can also damage cotton and synthetic materials.

The beetles perform functions of reproduction and establish colonies. Penetration of fertilized females into museum buildings and their laying eggs in the exhibits results in contamination of the whole museum by these beetles.

Beetles of *Anthrenus* species feed on flowers, and this fact is probably the necessary condition enabling the females to lay sound eggs. Young beetles born in the museum fly towards sources of light: windows, lamps, open doors. After flying out-into the open air, some of them are able to proliferate, the rest perish.

The life cycle of *Attagenus* can take place inside the museum, because they do not need any additional nutrition for normal reproduction. Thus one can admit that it is really possible for stable *Attagenus* beetle populations to appear in museums.

It should be noted that the death of many *Anthrenus* beetles museum buildings during their flight out of the should not make the museum workers' mind easy. As a rule, this flight continues for a very long time, besides the beetles there are always larvae which remain in the building and continue to damage the exhibits.

Unlike their larvae, leather-eating beetles possess well developed olfactory organs that are concentrated mainly in their antennae (Zaitseva, Elizarov, 1978). It enables them to find nutritious plants easily (more often those belonging to Umbellate and Rosaceae species and find partners for copulation. Desorientation of leather beetles by smells repelling them from museum exhibits could prevent the females from laying eggs on the exhibits and thus reduce the probable damage of materials by the beetle's larvae.

The published information about the olfactory responses of leather beetles damaging grain products and raw skins and furs (Pospisil Jaromir, 1973; Cohen Ephraim et al., 1974) is not complete and cannot be used in museums.

The proportion of insecticidal and repellent properties of paradichlorobenzene and naphthalene for leather beetles has not yet been established in spite of their wide application in museum practice (Arnold J.M., 1955; Batth Surat S., 1969; Piechocki R., 1979). Camphor and lavender oil are believed to prevent contamination of exhibits by moth and leather beetles. But experimental tests of the action of the smell of these substances on leather beetles have not been carried out. The problem of different response made by leather beetles of different species to the same smells has not been solved either.

The purpose of our work was to study experimentally the behaviour responses of leather beetles to the

smells of substances traditionally used in practice as repellents, as well as substances acting as repellents on gnats and fleas.

The experiments were conducted on fertilized females of particolored leather beetle - *Amthrenus picturalis* Sols. and Smirnov's beetle *Attagenus Smirnovi* Zhant. taken from laboratory cultures. Leather beetles of the species mentioned above are widely distributed pests in museums of our country (Zaitseva G.A., 1978). Experiments on particoloured beetles' females were made in autumn and in spring.

The behaviour responses of beetles to smells were fixed in the 12-channel olfactometer, designed specially for these experiments (Zaitseva, Zaitsev, 1980). The olfactometer channels pass radially from a round arena and end in traps. The beetles under examination are placed in the arena. A suction system put into action by an electric motor causes the air to move down the channels towards the arena. The speed of the air flow can be regulated by a special device damper. Beetles crawl from the arena in the direction of the air flow and fall into the traps. The number of test channels in which the air carries molecules of odorous substances is equal to the number of control channels. Before passing into the test channel the air passes through a funnel which contains a strip of filter paper coated with the solution of the substance. The area of the paper strip is 2 cm^2 , the amount of 1% solution in acetone is 0.04 ml. Equal distribution of beetles under the control channels and the experimental ones represents the absence of repelling or attracting properties of substances for leather beetles. We compared the quantities of beetles in the control and experimental traps and estimated the confidence of their average difference from zero. In the experiment the

quantity of *An.picturatus* was 50-80, that of *At.smirnovi* was 15-20 beetles. Uniform electric lighting was used during the experiments. Tests with the same substance conducted on every species of the beetles were repeated from five to 9 times. One experiment with particoloured beetle females lasted 45 minutes, while each experiment with the females of Smirnov beetles continued 30 minutes. The duration of the latter test is shorter because Smirnov beetles move faster than the particoloured ones.

Tests with the females of particoloured beetle were carried out in autumn (October, November) and in spring (April-May), in the summer period. Only those female beetles were selected for the autumn experiments, which were ready for hibernation and were in the state of diapause. A particular property of this species was used in the experiments - when the benumbed beetles were placed under an electric lamp, they showed their normal mobility. During the tests the males and the females of particoloured leather beetles were kept together. The boxes contained a substrate in which the females could lay eggs - woolen cloth, feathers. Every day a new wad of cotton wool soaked in water solution of honey was placed in the boxes. Nevertheless, not a single egg was laid by 60 females in the period of two months, which probably means that the beetles did not mate. The behaviour responses of the females to all substances (camphor among them) offered to them were indifferent.

It seems that in spite of the normal ability of beetles to move actively, the state of diapause covers all aspects of beetles' life. In this period all physiological functions of beetles become inhibited, and the sensitivity of females to various smells is greatly reduced.

The behaviour responses of particoloured leather beetle females (in the spring experiments) and those of smirnov beetle to smells of various substances are given in the results shown in the table. The symbol + means that the substance revealed repellent properties. A single plus means that the confidence of the difference between the control and the test was found for the confidence level equal to 99%. The symbol minus represents the indifferent attitude of beetles to the smell of the substance.

The table shows that paradichlorobenzene did not display any repellent properties toward both species of leather beetles. Naphthalene has repelling action only for Smirnov beetles. Camphor and lavender oil are very effective repellents both for the females of particoloured beetles and for those of Smirnov beetles.

N	Names of substances	Species of beetles	
		Anthrenus picturatus	Attagenus Smirnov'
1	Camphor	+	++
2	Lavender oil	+	+
3	Naphthalene	-	+
4	Paradichlorobenzene	-	-
5	RD-14	-	++
6	RD-28	-	++
7	RD-34	-	+
8	RD-47	++	-
9	RD-58	+	++
10	RD-67	++	+
11	RD-78	-	++
12	RD-87	-	-

Tests of new substances enabled the authors to choose RD-58 and RD-67 which proved to be repellents for both species of beetles.

It should be mentioned that the conclusions concerning the repelling action of substances for the level of confidence $P = 0.99$ are particularly strict, and therefore we consider it expedient to employ in museum practice substances marked ++ in the table.

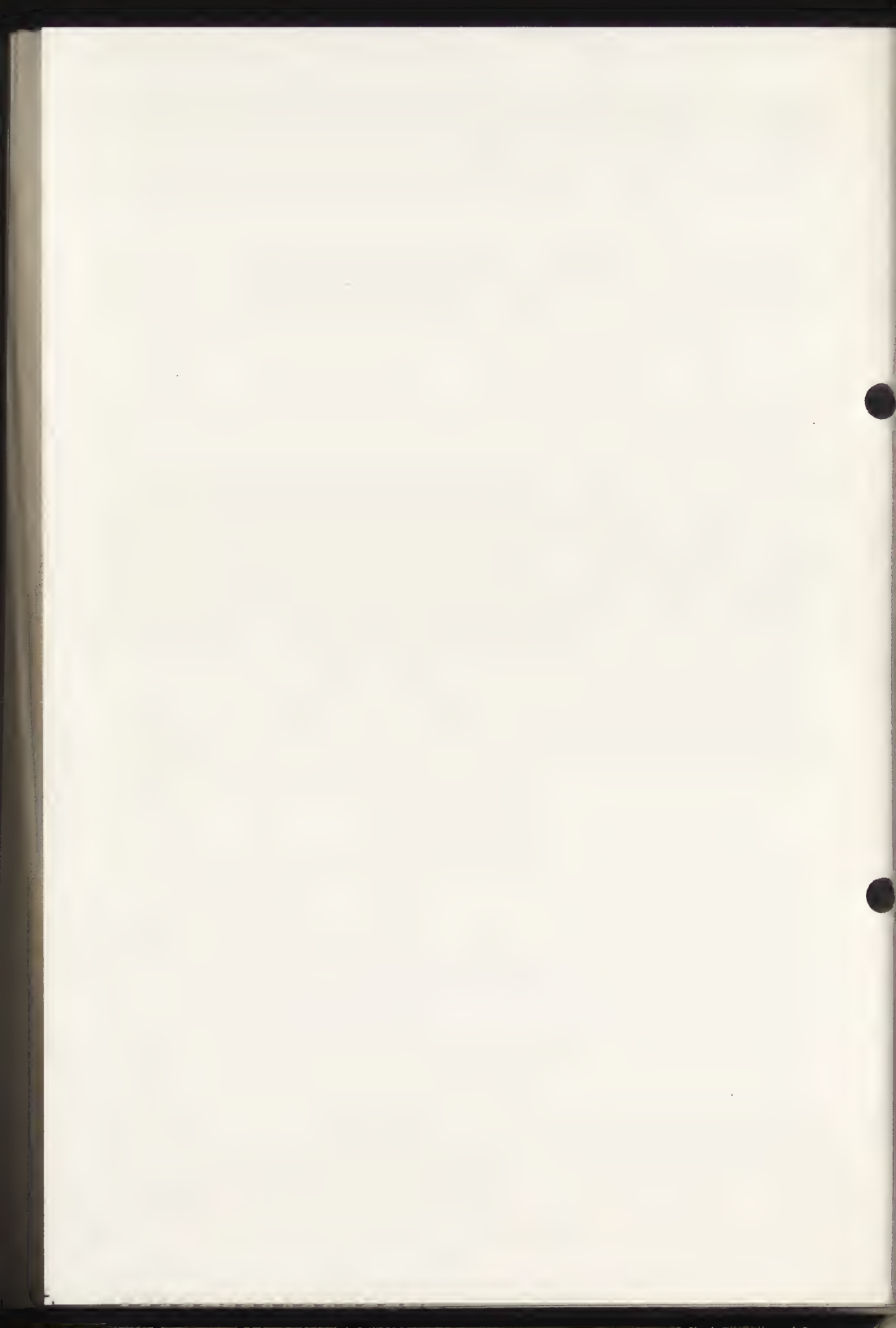
Comparison of behaviour responses made the same combination of substances by females belonging to both species to shows sharp difference in the perception of smells by beetles of different species. Females of Smirnov leather beetles proved to be more sensitive to the smells of substances offered to them.

The investigation made by the authors showed that leather beetles' response to smells of various substances depends both on the particular species to which beetles belong, and on the physiological condition of beetles. Substances repelling moth do not generally possess any properties that repel leather beetles. To protect museum exhibits we need combinations of repellents selected during tests with individual species.

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81/3/8

IDENTIFICATION OF VEGETABLE FIBERS OF
WOVEN ETHNOLOGICAL ARTIFACTS

Erika Schaffer

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Working Group: Ethnographic Materials

IDENTIFICATION OF VEGETABLE FIBERS OF WOVEN ETHNOLOGICAL ARTIFACTS

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ABSTRACT

Unless properly documented, ethnographic artifacts cannot be used as study pieces, which of course is their primary purpose in museums. The identity of the vegetable fibers, of which woven artifacts were manufactured, is one of the most important pieces of information. To identify these fibers or to correct erroneous identification a vegetable fiber identification method has been developed in the National Museums of Canada. In this work the micrographs of the inner bark fibers of cedar, maple, silverberry, alder, bitter cherry, the soft vegetable fibers of indian hemp, spreading dogbane, showy milkweed, stinging nettle, and leaf fibers of some monocotyledons are given both in surface and cross sectional view. The micrographs serve as standards in the identification of the fiber materials of West Coast artifacts. To confirm the microscopic identifications, the drying twist test is also carried out. A few illustrative case histories are also included.

1. INTRODUCTION

Native peoples discovered early in their history the technical importance of plant material. Because fibrous materials were used for the fabrication of household articles, for fishing, hunting and food gathering implements, these artifacts yield important ethnological information on the life style of Native peoples. A very large number of woven artifacts is included in the collection of the National Museums of Canada. The catalogue cards of the artifacts contain the description of the item and information on its origin. In many instances the material is identified but this is based on the collector's information, never on actual analysis. The verification of the material identity by a non-subjective method is obviously desirable and most useful for ethnological purposes. To this end, a systematic microscopic examination of fiber of artifacts

has commenced, limited to those fabricated by Native people of British Columbia from indigenous plant materials most common in the region. In the first stage of this project, photomicrographs representative of the most important fibers were obtained for reference purposes.

2. EXPERIMENTAL

2.1. Fiber Analysis by Microscope

Under the microscope the cross section and the surface along the axis of the fiber is examined.¹

The thin section for microscopic viewing of the cross section is prepared with the Mico Schwarz type manually operated fiber microtome (available from Mico Division, Latady Instruments Inc., P.O. Box 39, Accord, MA) (Figure 1). In this instrument the fibers, or a single fiber, folded in one-half inch segments is held in a vertical position securely in the slot of a steel plate. By operating the micrometer attached to the underside of the plate, a plunger is driven into the slot pushing the fiber bundle gradually out of the plate.

The preparative procedure of cutting a thin section entails the following steps: securing the bundle in the plate, pushing the bundle upward until a short length is exposed above the plate, impregnating the bundle with a drop of colloidon solution and then, after fifteen minutes, cutting the projected portion of the bundle with a razor blade flush with the surface of the steel plate.

The fiber is now ready for sectioning. The position of the graduated dial is noted, advanced so that a ten-micron-long section protrudes, which then is impregnated again with colloidon solution in order to maintain the fibers during sectioning in vertical position and to prevent the bundle from fraying. All cuts are made by hand with a safety razor blade held at approximately a thirty degree angle to the plate surface. The cut section is transferred onto a microscopic slide, mounted with plastic mounting medium, and examined under the microscope in transmitted light.

If the sample quantity available is insufficient for insertion into the microtome, the fiber has to be enclosed with a so-called filler. Any filament which is readily distinguishable and is structurally distinct from the sample can be used as a filler.

2.2 Drying Twist Test.

To confirm the microscopical identification, drying twist test² was found to be useful. This test is based on the finding that if a water-soaked single fiber, approximately 2.5 cm long, is permitted to dry over an electric hot plate so that one end is firmly held between forceps and the free end is facing the observer, the fiber may rotate either clockwise, counterclockwise or in alternating

directions. Most fibers rotate counterclockwise, but those classified under the nettle family - flax, ramie, various types of nettle - rotate clockwise. Cotton alternately rotates clockwise and counterclockwise.

3. FIBER MATERIALS³

3.1 Conifers

3.1.1. Cedars

Yellow cedar (*Chamaecyparis nootkatensis*) and Red cedar (*Thuja plicata*). Because of its qualities, the inner bark of the Yellow cedar is more valuable and was extensively used. It was made more pliable by pounding the water-soaked bark strips with whale bone on a flat stone.

The inner bark of cedar served as material for baskets, ropes, fishing line, nets, bags, hats, mats, blankets, ceremonial head-rings, armbands etc.

The bark fiber of all types of cedar show a similar structure. The oblong shape of the fibers in cross sectional view is a characteristic feature. The lumen is reduced to the width of a single line. When pounded while wet, the fibers of the bark are crushed and their structure disappears. (Figure 2)

The roots, too, were utilized for making nets, baskets, hats and mats. Roots were processed by heating them over fire, removing the bark portion and splitting it, depending on the diameter of the root, into two to four sections.

3.2 Flowering plants (Angiospermae)

Flowering plants are divided into two important subgroups: monocotyledons and dicotyledons.

3.2.1. Monocotyledons

Of the monocotyledons native to British Columbia the leaf and stem portions were utilized. These plants contain stiff lignified fibers, called leaf, or structural or hard vegetative fibers. Strong fibrovascular bundles, randomly distributed within the whole stem, terminate in the leaves as veins. They constitute a system for the transport of nutrients throughout the plant. In this group of plants belong:

3.2.1.1. Sedge (*Carex obnupta*) Swamp grass. The leaves were utilized for weaving baskets, usually having a cedar bark foundation. Only the leaves of the vegetative plants (female) were used; the outer leaves were discarded. The inner leaves were peeled off and split along the midrib into two parts which, in turn, were then twined over the bark foundation to form the weft. The leaves were sometimes twisted into cords. As they have a great affinity to dyes, they were frequently coloured. (Figure 3)

3.2.1.2. Bear grass, Squaw grass (*Xerophyllum tenax*). The leaves were used for making the weft portion in baskets and mats also for trimmings, imbrications and for decorations on birch-bark baskets. More recently, if these types of leaves were not available, they were substituted with corn husks. (Figure 4)

3.2.2. Dicotyledons

Several plants in this group are a source of bast or soft vegetable fibers. These fibers are associated with the fibro-vascular bundles located in the phloem region (inner bark) of the stem. In contrast to the monocotyledons they are not randomly distributed in the stem, but form a ring around the woody central cylinder, imparting strength and flexibility to the stalk. A wide range of herbaceous plants among the dicotyledons provide bast fibers. Of the trees and shrubs, the most noteworthy are:

3.2.2.1 Broad leafed maple (*Acer macrophyllum*). The inner bark is made into baskets with open-work weave, into rope and into tumpline. The cross section of the bark fiber shows a cluster of polygonal cells of similar size as that of *elaegnus*. The lumen is round. (Figure 5)

3.2.2.2. Silverberry (*Elaeagnus commutata*). Grows mainly in the dry southern interior of British Columbia. The inner bark was woven into bags, baskets, nets, mats, blankets and clothing as well as plaited into rope for tying and for fishing line. The braided strands were often intertwined with big sagebrush bark, indian hemp and white clematis bark. Often it was also dyed with various pigments. Because the cross-sectional outline of silverberry bark is very similar to that of maple, identification and differentiation from one another is difficult. (Figure 6)

3.2.2.3. Big sagebrush (*Artemisia tridentata*). Is common in the dry interior British Columbia. The fresh bark has a strong aromatic scent. It was woven into mats, bags, baskets, quiver cases, saddles, blankets, dresses, skirts, aprons, breechclouts, ponchos, capes and shoes. Often it was woven together with other fibrous materials, such as willow bark, red cedar, silverberry and indian hemp and twisted into a long rope. The microscopic cross section shows similar cell structure to maple and silverberry bark, but the size of the cells is much larger and this can serve as a basis for identification. (Figure 7)

3.2.2.4. Alder (*Alnus*). Three varieties occur in British Columbia. The inner bark was made into cord and fishing nets. The cross section of the bark is distinctly different from the ones mentioned before. (Figure 8)

3.2.2.5. Bitter cherry (*Prunus emarginata*). The shiny bark was used to imbricate baskets, mats and bows. Twisted into string, it was woven into fishnet. It can be easily recognized by viewing under a microscope in cross section, (Figure 9) and by the red-coloured shiny surface appearance. Occasionally it was, however, coloured

black. The bark, in contrast to those previously mentioned, was pulled off horizontally from the tree and cut into a helix.

Among the dicotyledonous herbs, the bast fibers of indian hemp, spreading dogbane and showy milkweed were mostly utilized by the Native peoples. Not being of commercial interest, the structure of these fibers has never been studied. Also, in contrast to tree bark the morphological features of these vegetable fibers are sensitive to factors such as growth conditions (soil, climate), the degree of maturity, the location in the stem and the applied processing method. For these reasons, differentiation between these species is, an extremely difficult task.

Moreover, as it was quite common that in the spinning of twine the Native people did not limit themselves to the fiber of a single plant species, it is difficult to obtain a reliable reference material. For this reason no attempt will be made here to differentiate between these three fiber species.

3.2.2.6. Indian hemp (*Apocynum cannabinum*). Is common in the interior of the province of British Columbia. The stems of this plant were harvested when the leaves were turning yellow in the fall. The branches and leaves were removed and the stems flattened by pulling them around a pole tied to a tree trunk. The stems were then split open, the outer skin peeled off and the inner fibrous parts hung up to dry. By pounding or twisting the dried stem, the pithy portion was separated and the fiber was freed. Spinning of the fiber was carried out on the bare thigh with damp hands. The fibers were joined together in the form of an interlocking "Y" and rolled together until they became intertwined. Stronger ropes were produced by increasing the number of strands plaited together.

Indian hemp is comparable to flax in tensile strength, texture, colour and chemical composition. Because of its strength, the light tan-coloured processed fiber was used for fabrication of fishing lines, fishing nets, bridle ropes, sewing thread and mats. It was also used for weaving cloth for bags, garments and other articles. Indian hemp was often woven together with the bark fibers of silverberry, willow, sagebrush or with tule.

Under the microscope one can detect cross-marks on the fiber surface, which are caused by the processing. The cross section of fibers, documented in the National Museums of Canada collection as Indian hemp, ranged from polygonal, to oval and to round. The lumen varied between elliptical, round or was often not even detectable. (Figure 10)

3.2.2.7. Spreading dogbane (*Apocynum androsaemifolium*). In contrast to indian hemp, spreading dogbane grows in all regions of British Columbia and was used extensively, although the fiber was regarded to be inferior to that of indian hemp. Dogbane was also often used to supplement the more valuable indian hemp. The cross section of the fiber is round to oval. (Figure 11)

3.2.2.8. Showy milkweed (*Asclepias speciosa*). Grows in the southern interior British Columbia. Although this fiber is very soft and strong, it is considered of inferior quality and was used for making twine when indian hemp was not available. The cross section of this fiber appears similar to nettle, but it is much smaller in size. (Figure 12)

3.2.2.9. Stinging nettle (*Urtica dioica*). *Urtica dioica*, a perennial plant is one of the three types of stinging nettle. It yields the largest amount of fiber, although not sufficient to make industrial processing economically feasible, except at times of fiber shortages such as during wartime. Fiber yield is only 20 percent of the weight of the inner bark. The plant is common both along the coast and in the interior of British Columbia. The stems were gathered after the plant had completely matured and was beginning to die in the fall. The leaves were stripped off and the stems were dried in the sun or over fire as was done on Vancouver Island. The outer skin was cracked off and the fiber was separated from the inner pith. Spinning was carried out on the bare thigh. The individual strands were spliced by rolling. The threads were twisted into a two to four ply twine, used for making tumpline, snares, fishing line, fishing net, duck net, etc. In industry, the fiber is retted in water to destroy, through bacterial action, the parenchymal tissues and the water insoluble pectins which glue the fibers to each other and to the woody core. The length of the process is critical as overretting causes breakdown of the fibers. Retting is followed by a chemical treatment.

The length of the obtained fiber is 5-7 cm and has a diameter of 0.01-0.04 mm. The single cells are 15-30 mm long. The tensile strength of the fiber is high, similar to that of flax.

Under the microscope, fine oblique striations are visible on the surface of the fiber, the ends of which are finely pointed. (Figure 13, 14) The individual fiber is also unevenly marked, creased and, in part, ribbon like. The lumen is small or of medium size and often contains a yellow substance. The cross section of the fiber is oval, flattened or occasionally even has the walls turned in. The walls themselves are thick and stratified with the inner layers frequently radially marked.

The processed fiber is supple, soft to the touch and similar to ramie. It is of pure cellulose with occasional traces of lignin.

4. CASE HISTORIES

4.1.

Artifact Cat. No. VII.X 321 is described in the catalogue as a bark cordage. The microscopic analysis of the fiber cross section revealed the oblong outline of the cell with the characteristic narrow lumen. By this feature it was identified as cedar bark.

4.2.

VII.B 693 is a net used by the Haida Indians for catching large salmon and dog-fish. According to information obtained by the collector, the net was made of cedar bark. The cataloguer, however, questioned the accuracy of this statement and raised the possibility that the net was made of nettle fiber.

The microscopic examination of the sample taken from the artifact did not give a clear indication as to the nature of the fiber. Because it was suspected that this was due to the shrivelled state of the fiber, the sample was soaked in water to restore its normal dimensions. The swollen fiber rotated clockwise in the drying twist test. The dried material was also cross sectioned in the microtome. This time the characteristic oval-shaped outline of nettle and its lumen and the radial marking of the inner layers could be clearly detected under the microscope, thus clarifying the nature of the material.

4.3.

Cat. No. II.B 6 is catalogued as cedar bark thread material, thinly shredded, held in knotted loop. It appears, however, that because of the characteristic cross section and narrow polygonal cells, the fiber is indian hemp. This fiber is very coarse, having a high lignin content. It does not rotate on drying. (Figure 15)

4.4.

VII.G 426 is a backstrap of unidentified fibers, of coastal Salish origin. In cross section, small clusters formed by less than 30 fibers were visible proving that it was not a leaf but a bast fiber. The shape of the cells was polygonal with a clear round lumen. It rotated counterclockwise in the drying twist test, and was assumed to be indian hemp. (Figure 16)

A similar fiber interwoven with bulrush was also found in the fabric of a cord, Cat. No. VII.G 433. (Figure 17) This fiber also rotated counterclockwise in the drying twist test.

4.5.

Cat. No. VII.X 58 is a three piece suit made of cedar bark. The fabric is composed of shredded cedar bark bound by rows of twined cord spaced one-quarter inch apart. The cord was thought to be nettle. However, the sample taken in surface view had the appearance of a twisted ribbon, and in cross section showed the outline of oval, round and bean-shaped cells with lumen. This is characteristic of cotton. (Figure 18)

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I am especially grateful to Mr. Sterling Presley, Archaeological Survey of Canada for his cooperation and assistance in my photomicrographic work and to the Photographic Section, National Museums of Canada for preparing the prints.

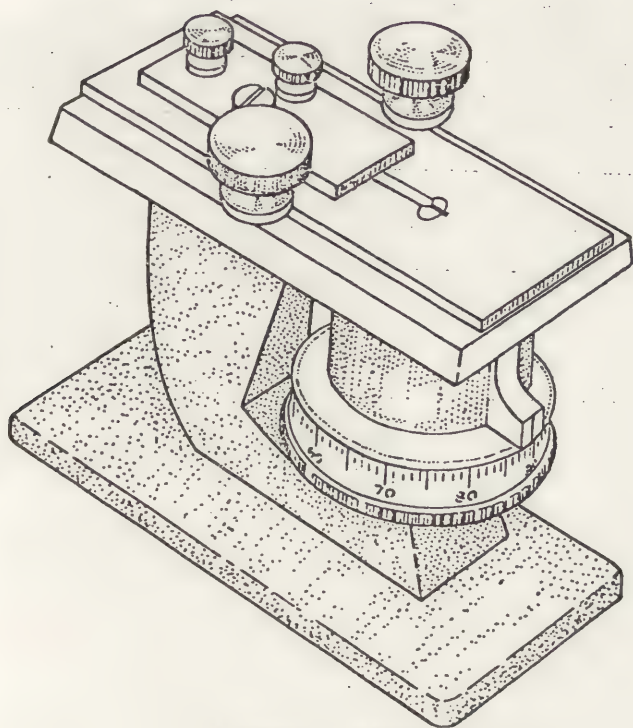


Figure 1. Fiber Microtome

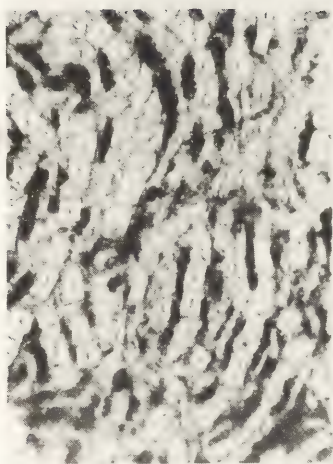


Figure 2. Cross section of
(x100) cedar bark fiber

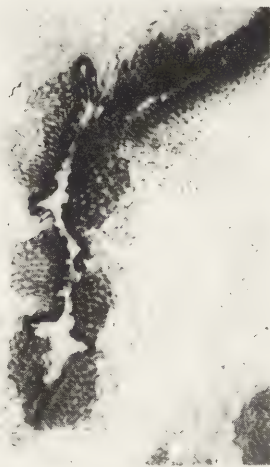


Figure 3 Cross section of
(x200) sedge

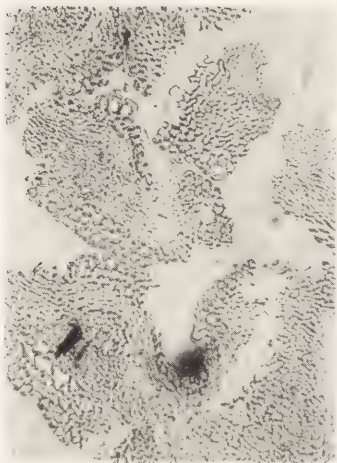


Figure 4. Cross section
(x100) of bear grass

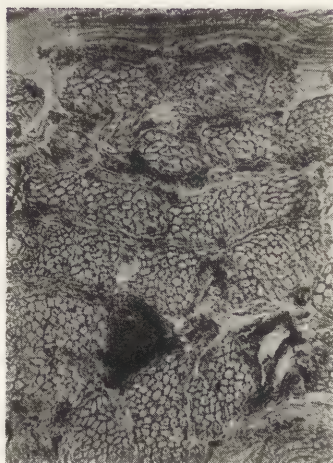


Figure 5. Cross section of
(x100) maple inner bark

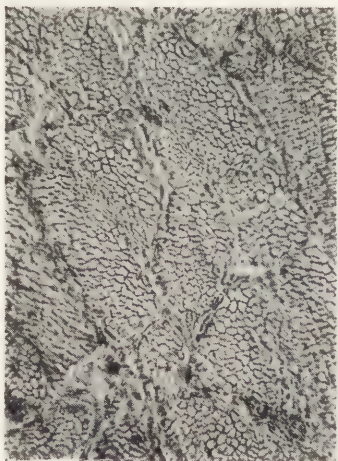


Figure 6. Cross section of
(x100) silverberry bark

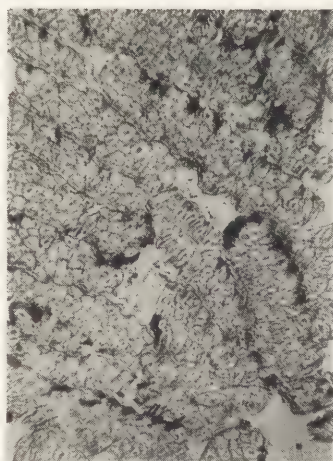


Figure 7. Cross section of
(x100) sagebrush bark



Figure 8. Cross section
(x200) of alder bark



Figure 9. Cross section of
(x200) bitter cherry bark

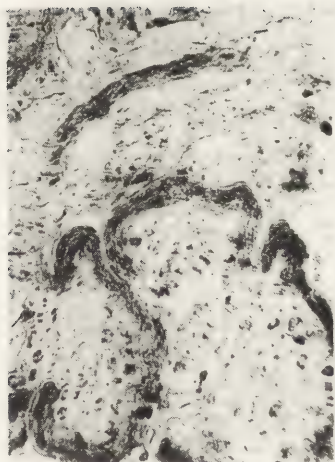


Figure 10. Cross section of
(x200) indian hemp fiber

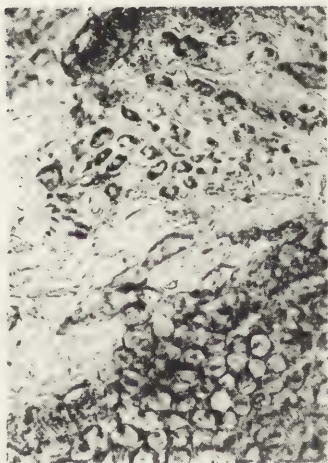


Figure 11. Cross section of
(x100) spreading dogbane
fiber

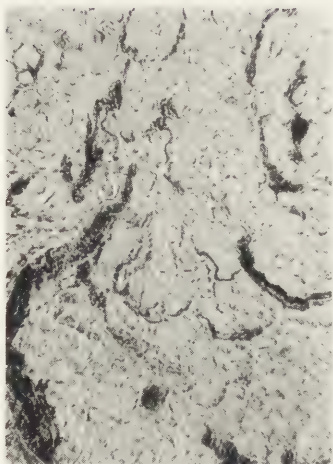


Figure 12. Cross section of
(x100) milkweed fiber

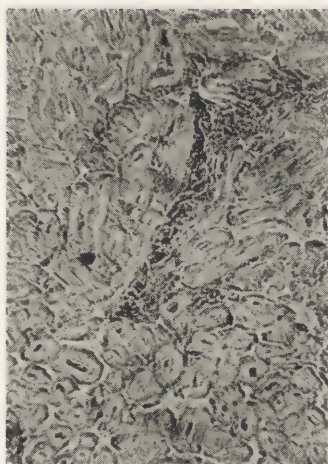


Figure 13. Cross section of
(x100) nettle fiber



Figure 14. Surface view of
(x100) nettle fiber



Figure 15. Cross section of
(x100) fiber of artifact
II.B 6

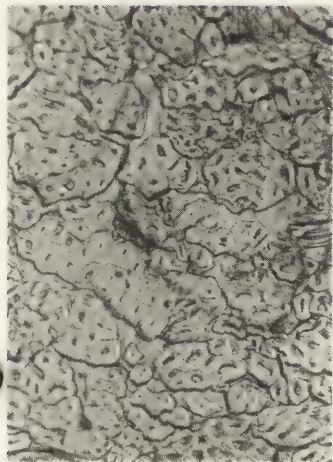


Figure 16. Cross section of
(x200) fiber of artifact
VII.G 426



Figure 17. Cross section of
(x200) fiber of artifact
VII.G 433

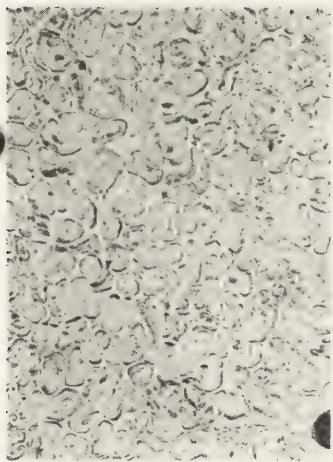


Figure 18. Cross section of
(x200) cotton of artifact
VII.X 58

ETUDE METALLOGRAPHIQUE DES TECHNIQUES DE
FONTE DE QUELQUES CRUCIFIX EN METAL DU
BAS-ZAIRE ET DE L'ANGOLA DU NORD

Huguette van Geluwe

Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981

Groupe de travail: Matériaux ethnographiques

ETUDE METALLOGRAPHIQUE DES TECHNIQUES DE FONTE DE QUELQUES CRUCIFIX EN METAL DU BAS-ZAIRE ET DE L'ANGOLA DU NORD

Huquette van Geluwe

Musée Royal de l'Afrique Centrale
1980 Tervuren
Belgique

I. Matériel d'Etude

Série de crucifix, apparemment en laiton mais de types divers, originaires des Kongo au sud du Fleuve (région frontalière Zaire-Angola). Certains types sont certainement de fabrication locale, d'autres semblent d'origine européenne ou coulés sur modèle européen.

II. OBJET DE LA RECHERCHE

A.- Détermination des techniques de fabrication et de la matière :

- Coulée à moule ouvert ou fermé
- Moulage en un ou deux temps
- Température de coulée
- Nature des métaux et des alliages
- Techniques particulières

B.- Essai d'établissement de l'origine des pièces par l'examen métallographique

- Métal d'origine locale ou d'importation (européenne ?).
- Alliages réalisés localement ou en Europe.

III. PLAN DE TRAVAIL

A.- Travaux de préparation; contacts et investigations - établissement du budget.

B.- Classement des pièces.

Catégorie 1. : Crucifix de "type africain" coulés en une pièce.
(croix, Christ orants et gisants ev.) exclusivement
en métal jaune.

Catégorie 2. : Figure du Christ en "position crucifiée", la face
dorsale marquée de stries curvilinéaires; style conforme
aux canons européens; métal jaune ou rouge.

Catégorie 3. : Christ en "position crucifiée"; face dorsale sans
stries particulières; style européen, métal jaune ou rouge.

Catégorie 4. : Christ en "position crucifiée" de style africain;
métal jaune ou rouge.

Catégorie 5. : Christ seul, en "position crucifiée" en plomb ou en
alliage à bas point de fusion.

C.- Observation et description détaillée de chaque pièce.

- 1.- Mensurations
 - proportions
 - poids
 - densité
 - couleur du métal (cuivre, laiton, bronze).
- 2.- Marques de coulée
 - empreinte du moule
 - plans de séparation des phases de coulées
 - qualité de la coulée
 - examen des jonctions des motifs
 - qualité des formes et reliefs du moulage
 - ajoute de métal pour rendre des volumes (souvent au dos) ou combler des lacunes ou rectifier une forme
 - soudure métal contre métal
 - trace de martelage, de limage, de ciselage, de burinage ou de forage
 - point de flexion
- 3.- examen particulier des membres et leur façon
 - superposition des pieds par martelage ou fondu en bloc
 - ajoute de métal pour les mains et clous en relief
- 4.- étude et réflexions sur les possibilités technologiques
- 5.- examen stylistique

D.- Photographie de l'ensemble et du détail pour la mise en évidence
des observations.

E.- Investigations au RX (non destructive)

- 1.- Cliché RX pour chaque pièce
 - une vue de face
 - une vue de profil des pièces de la catégorie 1
 - éventuellement une vue modulée pour faire apparaître certains détails situés à des profondeurs différentes dans la pièce.
En fonction du pouvoir de pénétration des RX à travers le métal,
mise en évidence de : jonction de coulées, surcoulée, bavure,
jonction de pièces, détails fins (stries).

- 2.- Examen et interprétation des clichés mise en évidence de détails non visibles ou suggérés visuellement.

Exemple :

- qualités différentes de coulée de métal
- jonction invisible
- défaut, bulle, bavure
- creux caché
- modification d'une pièce

L'examen de certains détails à la loupe binoculaire sur le cliché.

- 3.- Examen comparatif entre la pièce et son cliché RX.

- 4.- Critique et limite de la méthode.

F.- Investigations métallographiques proprement dites.

1.- Technologie

- a. métal ou alliage (composition élaboré sur place ou d'origine européenne)
- b. pièces coulées en plusieurs étapes ou en une seule fois
- c. utilisation d'un agent fondant pour la soudure métal/métal
- d. phases de coulée
- e. température de coulée.

2.- Techniques d'investigation :

a. Méthode non destructive : Fluorescence X

Analyse des pièces entières au microscope électronique e.a.

- mise en évidence par graphique des pics des métaux composants.
- répartition éventuelle de ces métaux.
- analyse visuelle des surfaces en vue largement submicroscopique.
- analyse métallographique ponctuelle sur la surface étudiée.
- prise de vue des points précédents.

b. Méthode destructive (uniquement dans le cas où la lère méthode s'avère inconclusive) :

Prélèvement d'une microcarotte de sondage dans la pièce + étude et analyse longitudinale de celle-ci.

L'analyse par voie chimique de tournures prélevées sur les pièces n'a pas été envisagée ici.

Certaines pièces ont déjà subi cet examen dont le résultat sera communiqué.

Pour les autres pièces cette investigation reste toujours possible si elle est nécessaire.

G.- Reconstitutions expérimentales :

Deux possibilités :

- 1.- coulée par analogie avec un métal à bas point de fusion -le plomb
- 2.- coulée avec un alliage le plus proche de celui des pièces.

A résoudre :

- Techniques de coulées.
- Problèmes des moules (ouvert ou fermé)
- Problème des stries (cfr. pièce de la catégorie 2)
- Techniques de façonnage
- Techniques de soudure.

Etude fait en collaboration avec la
Section d'Economie Agricole et Forestière
(Service d'anatomie des bois tropicaux).

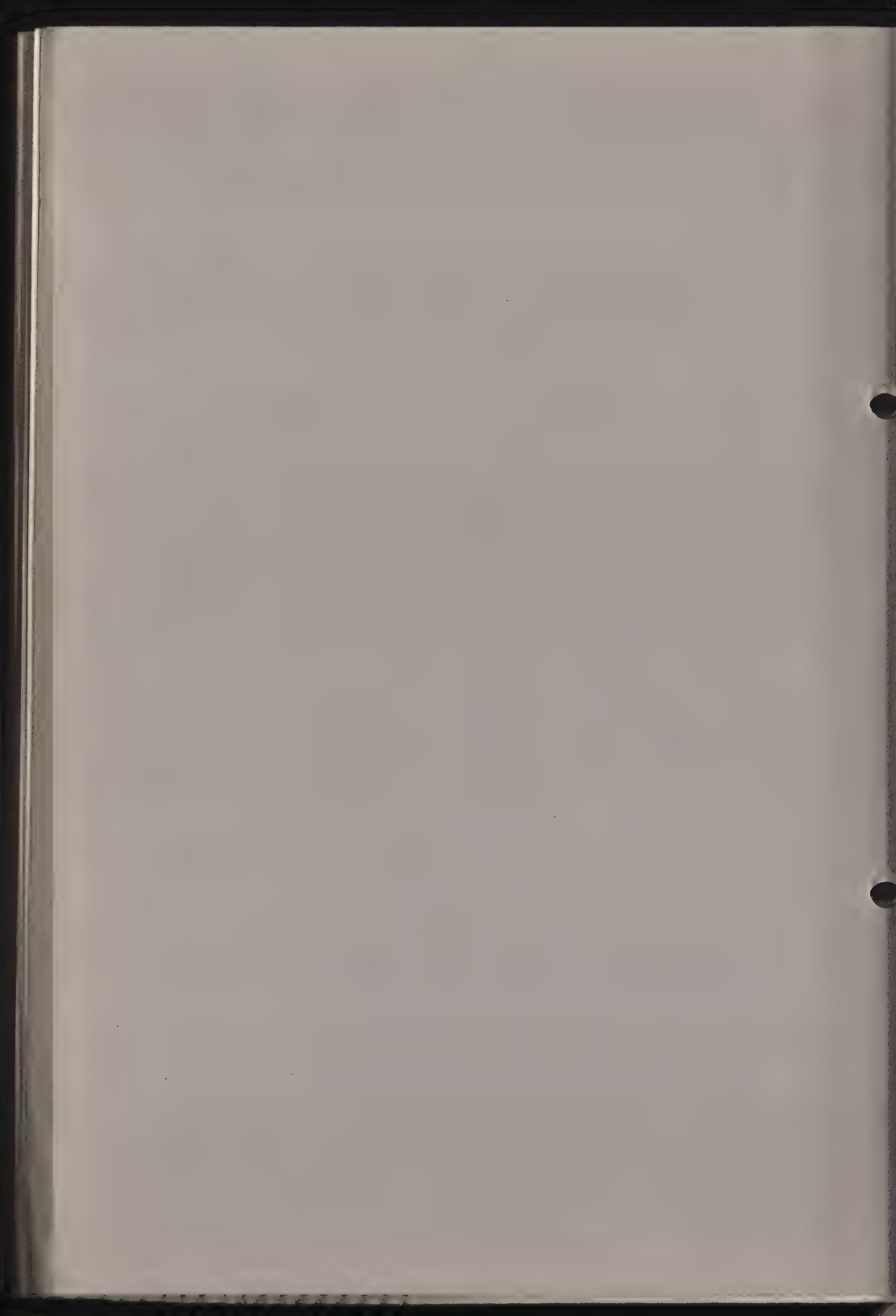
81/3/10

THE CONSERVATION OF A LIVING ARTEFACT -
A MAORI MEETING HOUSE AT MAKAHAE.
A PRELIMINARY REPORT

K.M.Peters

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Ethnographic Materials



THE CONSERVATION OF A LIVING ARTEFACT - A MAORI MEETING
HOUSE AT MAKAHAE. A PRELIMINARY REPORT

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This paper is concerned with the conservation of a living artefact - a New Zealand Maori meeting house which is still very much in use but deteriorating as a result of climatic conditions. Conservation techniques, conservation ethics, and the attitude of Maori people towards the conservation of their cultural heritage are discussed.

Introduction

The conservation of artefacts held in museums can be dealt with on a purely technical level taking ethical conservation standards into consideration. However, dealing with artefacts which are still in use by indigenous people, and are still very much part of their lives, is a very different problem. Not only has one to deal with the technical problems, but also with the people and their attitudes towards the conservation of their heritage. The involvement of, in this case, non-Maori people is a twofold problem. On the one hand it is a political problem, with the political awareness of some of the Maori people who feel that it is inappropriate for Pakeha (Europeans) to work on their artefacts and that the work should be carried out by Maoris only. On the other hand, there are those in the Maori community who believe that carvings and the like which depict their ancestors should die a "natural" death. They feel that just as mortals pass on in time, so do the carvings and artefacts.

It is against this background that the conservation of this Maori meeting house took place. I would like to discuss the conservation of a house which is in constant

use, is part of a living culture, and is a "living artefact".

The involvement of the owners of this meeting house was very much part of this project which was undertaken to make Maori people aware of the possibilities available for preserving their cultural heritage and of what can be done to prevent the deterioration of their houses, carvings and other artefacts.

The New Zealand Historic Places Trust, which is funded by the New Zealand Government, has a Maori Advisory and Buildings Committee which has Maori representatives on it. It gives advice and financial help to Maori communities to restore or look after their cultural heritage. Unfortunately, due to the lack of trained ethnographic conservators, there has not always been professional control or records kept of what has been done. Consequently there have been unfortunate experiences.

There is a great need for the conservation of these living artefacts. It is estimated that there are some 2000 Maori meeting houses alone, all in need of some degree of attention. The development of techniques and approaches to help prevent deterioration is an extremely important area for research in New Zealand but it has not received the attention it deserves. The problem is urgent. Climatic conditions, insects and wood fungi are destroying much of the cultural material which is exposed in field conditions. As one Australian conservator recently pointed out: "government and individuals alike need motivation to tackle the problem that is technically complex, potentially expensive and difficult to solve on ethical and political grounds".

Conservation ethics which are applied in a museum cannot be applied in the same way in respect to Maori maraes. For example, the preservation of existing painted decorations: should there be total cosmetic restoration, i.e. total overpainting and maybe the use of new forms; or preservation of the existing surface? The meeting houses are living structures and thus attitudes of the owners have to be taken into account. However the point of view of the conservator should also be made known to the owners.

In this project discussions with the owners of the house took place, the Maori people were shown the deterioration and why it took place, various methods and approaches were discussed, and with the full cooperation of the local people a decision was made on how to tackle the problem.

Restoration

Condition before conservation

The bargeboards or maihi of the meeting house measure 7 metres 35 cm x 0.65 cm. They had suffered badly from dry rot and weathering. Only the front of the carvings had been painted and, with the roof-flashing applied in an unprofessional manner, rainwater had a free flow on the back of the boards. Consequently rot developed which resulted in a split throughout the entire length of the boards and the subsequent breaking of the boards into 4 segments. The dry rot had free range to attack the wood and in several places the surface of the carving detail was completely rotted away. In other places rot came within 1 or 2 millimeters of the surface. Attempts had been made to stop the spread of the deterioration by applying putty into the gaps. This of course resulted in a very unsightly mess.

The carvings, amo, standing in front of the bargeboards and the carved head, koruru, placed on the apex of the maihi were very weathered and had a poor coat of paint. The feet of the amo were placed in concrete which had resulted in dry rot attack.

Conservation process

The amo, maihi and koruru were removed from the house without additional damage. After consideration of the paint surface layers it was decided to remove the paint. There were two reasons for this. Firstly, on all the carvings the various repaints had resulted in complete obliteration of the fine carved detail. Secondly, the paint was in a very poor state. A red oxide roof paint had been used and this had been allowed to deteriorate to such an extent that a touch-up job was out of the question. The local people were shown how to tackle the job with care and we had a daily team ranging from 4 to 12 people on the job. Paint samples were taken before the paint was removed with methyl chloride and hydrocarbon solvent solution. After removal of the paint the carvings were washed three times to remove any residue of the solution. Difficult-to-get-at places were given an extra two or three rinses. The local people did a splendid job and this saved us a lot of time. It also instigated a tremendous interest in nearby communities which resulted in constant visits during the work. Although time was lost talking to these visitors, the advantage gained was that they started to think about their own meeting houses and what they could do, and we had constant questions asking advice.

After the removal of the paint the areas infected with dry rot were impregnated with a low viscosity aliphatic epoxy resin which gives extremely good penetration into the wood and improves the mechanical properties and weather resistance. Its trade name is Epsilon El200. Missing parts of the carvings were filled in with epoxy resin mixed with fine sawdust and then carved. After the impregnation, which was carried out by injection with a syringe and application by brush, the segments were glued together with epoxy glue. An angle iron frame is to be manufactured which will support both the top and bottom edge of the maihi, thus reducing the strain on the maihi. A mastic compound will be applied on both sides so that rainwater cannot run along between carving and angle iron.

The amo after cleaning were turned upside down to impregnate the feet which had dry rot attack. The same consolidant was used as for the maihi. The weathered parts and grooves on top of the head were sealed with an epoxy sealer and antifungicide.

The paint samples taken from the carvings will be used to have an acrylic paint made up by a paint manufacturer to exactly the same colour as the original paint. This will be sprayed on in order to eliminate the paint build-up in the fine carved details.

The painted decorations in the porch and house

The side walls of the porch consist of 4 vertical panels which support the rafters above, interspersed with imitation reed panelling. Half-way up is a narrow horizontal band across all these panels. When we began work the support panels were painted with red oxide, but showed faint traces of black and white decoration underneath. The imitation reed panelling was painted white. The horizontal band was painted the same colours as the panels, but showed traces of pattern underneath. The rafters above were decorated with black and white kōwhaiwhai patterns. The white had been overpainted, and it was the poor quality of this overpainting which made us approach the local people to discuss the possibilities of a more professional repaint. It was agreed also that we should remove the paint from the horizontal strip to reveal the decoration below. The boards were cleaned with a paint-stripper, taking care that the original patterns were not further damaged. The patterns were revealed to have been black and white where the band was attached to the uprights, and blue, red and white where it was attached to the reed panelling. While working on this we discovered that the

panels themselves had also originally been different colours -- the support panels had been white, and the reed panelling cream in imitation of the genuine reed panelling of earlier houses. After further consultation with the Maori people it was decided that we should restore all the panels to their original colour scheme.

After cleaning the over-paint the kōwhaiwhai patterns were consolidated with Paraloid B72 10% solution in acetone so that the original surface is preserved. They were then repainted. It was decided to use satin gloss acrylic paint as the original paint was also of a semi-gloss nature. Samples of the remaining blue paint were taken so it can be matched by paint manufacturers as none of the available commercial paints are near the original colour.

Inside the house is elaborately decorated, again in black and white, and again the white patterns had been over-painted in an attempt to cover the grime which had covered them. In fact the decorations are in reasonably good condition and there is no real need for overpainting. Tests were made to see what was the best agent to remove the grime. Acetone, toluene, white spirits were not very successful - they either did not remove the grime or they removed the grime and the paint. A solution of Lissapol 5% and ammonia 5% in water v/v was the best agent; it removed the grime without attacking the painted surface. This will be used when the inside of the house is cleaned in May when the project will be continued. After cleaning the decorations will be consolidated with Paraloid B72 10% solution in acetone.

Conclusion

In this conservation project of a living artefact belonging to indigenous people, it was demonstrated that a project like this can be undertaken, taking careful consideration of the attitudes of the local Maoris, and without causing friction within the community. In this case the Maori owners were quite willing to accept conservation ethics of preserving original decorative designs and carvings instead of the often adopted cultural attitude that carvings, decorations and other artefacts should die a natural death.

At the time of writing this article the project is not finished. It is hoped that it will be concluded in May.

Acknowledgements

I would like to thank Mr A. Barton and Ms Sabina Weik for assisting me in this project.

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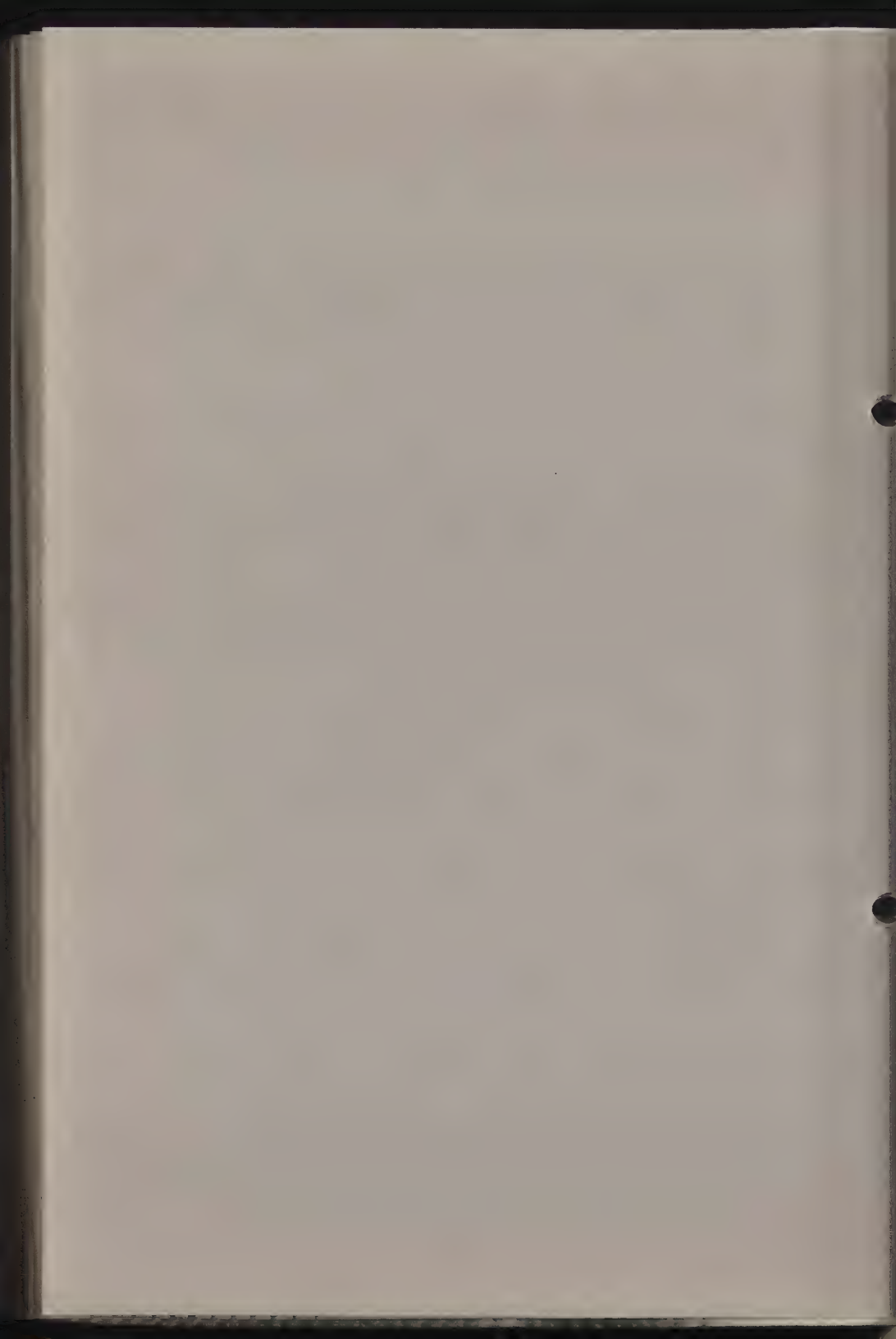
81/3/11

TRADITIONAL CONSERVATION PRACTICES AMONG
THE NORTH AMERICAN PLAINS INDIANS.
A SUMMARY OF WORK IN PROGRESS

Lisa Mibach

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Ethnographic Materials



ADDITIONAL CONSERVATION PRACTICES AMONG THE NORTH AMERICAN
PLAINS INDIANS. A SUMMARY OF WORK IN PROGRESS

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ABSTRACT

This preliminary report describes an ongoing project, which is intended to extend over several years, of information collection on materials and methods used by North American Indian people to make and to preserve artifacts.

The project is based on fieldwork with members of the Blackfoot, Blood, Cree, and Sioux tribes of the Plains Indian group, and is intended to supplement descriptions in the ethnographic literature and to document traditional conservation philosophies and materials.

The results are intended to provide information for the development and choice of modern conservation treatments, and to assist in sampling and analysis for the identification of materials.

Research to date has already yielded a body of conservation principles which predates our own by hundreds of years. These define who is allowed to handle specific types of material; frequency and methods of maintenance and storage; and use compatibility of materials as a basis for the choice of treatment methods.

DESCRIPTION OF THE PROJECT

Purpose

Many of the significant collections of artifacts of the material culture of the varied cultural groups known as the North American Indians are now in the collections of museums around the world. From these artifacts are drawn inferences on past technologies and ways in which these groups adapted to their environments. All too often, conclusions are based on stylistic grounds alone: this may be because scientific analyses of the materials have not been done (or the right questions have not been asked), or because the object has been so changed by cleaning and restoration that the evidence is forever lost.

The conservation of ethnographic material presents problems not found in the conservation of historic material: for example, when is "dirt" an undesirable accretion and when is it part of the ritual history of an object? We are dealing largely with deteriorated organic materials, which are difficult to analyse in a normally equipped conservation lab. It is therefore possible that in our attempts to reveal the object as it originally was, we may unintentionally remove a significant component (e.g. a waterproof coating) without ever having known it was there.

Unfortunately, we cannot rely on the ethnographic literature for information to assist us in making decisions affecting cleaning and treatment. Early ethnologists and anthropologists had the opportunity to observe these peoples in their daily lives, but their attention was more often drawn to social and religious activities than to technologies, so that often the specific technical information we need is inadequately or incorrectly described.

Our approach to treatment of an artifact is usually based on the condition of the individual component parts. However, since ethnographic conservation is still somewhat experimental, we may find, in the traditional practices of the people who made the objects now entrusted to us, ideas for modern treatments which will be compatible with the philosophy, technology, and purpose of original manufacture.

We are fortunate in Western Canada to have access to a number of Indian tribes. Many of the old people still remember, or practice, traditional ways of doing things. The author has therefore begun a five year project aimed at gathering information from these old people, on how artifacts were made, and, particularly, on traditional methods of preservation. It is hoped that this information will be useful in the development and choice of modern treatment methods, and will assist in the sampling and analysis for the identification of materials.

Research Method

The ethnographic and ethnobotanical literatures are being surveyed, but the primary emphasis of the project is on interviews with Indian people who still remember the old ways. The first phase of the project concentrates on the Blackfoot, Blood, Cree, and Sioux tribes. Later phases may expand the geographic and cultural areas if sufficient contacts and information become available.

Questions being asked include:

- 1) materials and techniques of manufacture;
- 2) was the object treated in some way to make it last longer or work better (physically or ritually), (for example oiling or waterproofing); with what? Why?
- 3) how was this type of object cleaned? With what? How often? At any special time of year?
- 4) quantities and proportions of treatment materials and tools used;
- 5) sources of materials;
- 6) modern use of commercial materials (e.g. silicone spray on dancing mocassins; "Downy" fabric softener used during hide tanning).

The research results to date will be available to the ICOM Committee for Conservation at the September, 1981 meeting.

The differences in philosophical approach to preservation between the modern museum profession and traditional societies will also be explored.

Finally, since we are dealing with living cultures, we hope to be able to provide a network of knowledgeable Indian people who are willing to help museum professionals with specific questions and problems.

Any colleagues who are interested in contributing to the project are urged to contact the author at the address above.

DOCUMENTATION

Coordinator : Y. Grenberg (USSR)

Assistant coordinator: S. Bergeon (France)

Members : I. Bogovčić (Yugoslavia)
 Y. Cher (USSR)
 T. Kiss (Hungary)
 N. Majcen (Yugoslavia)
 E. Pacoud-Rème (France)
 R. Organ (USA)
 A. Skovran (Yugoslavia)

Programme 1978-1981

- La documentation de musée (de restauration et technique) et l'élaboration des systèmes; information - recherche.
 Les indices de classification de différents objets d'art pour leur introduction dans les systèmes d'information.
- I. 1. To prepare the recording cards for printing, to collect and discuss the experiences of the conservators working with them.
 2. Further elaboration works - text - book, register of the chemicals, and object types.
 3. To cooperate with computer experts for the elaboration of the programs.
 4. 11. International Museological Seminar in 1979 on the documentation of museum objects.
 5. Elaboration of a system for the documentation of art objects - collaborating with the ICOM and the ICCROM. (Kiss).
- II. 1. Rassemblement des remarques sur le Thésaurus provisoire présenté en 1978.
 2. Elaboration du Thésaurus définitif et présentation des problèmes de codage pour le rendre opérationnel. (Bergeon pour Pacoud-Rème).
- II. 1. Continue present uses and develop the data-base.
 2. Test use of commercially-available data-bases in chemistry etc. for use in solving problems of conservators.
 3. Develop on-line contact with AATA or show that this is uneconomic.
 4. Collaborate in development of thesauri.
 5. Collaborate in developing standards for storage of analytical data so that data acquired by one laboratory may be machine-accessible to others. (Organ).
- IV. Utilisation des symboles dans la documentation graphique (Bogovčić).
- V. Utilisation des ordinateurs dans les travaux pratiques de musée (Cher).
- VI. Méthodologie de la documentation des monuments ornés par les fresques - particulièrement dans le cas de l'enlèvement des fresques et du transport des monuments (Skovran).

SYMBOLES GRAPHIQUES DANS LA DOCUMENTATION
CONCERNANT LA RESTAURATION

Ivan Bogovčić

Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981

Groupe de travail: Documentation

SYMBOLES GRAPHIQUES DANS LA DOCUMENTATION CONCERNANT LA RESTAURATION

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La documentation des interventions de restauration manque toujours d'unité et elle diffère d'un auteur à l'autre. Cela vaut avant tout pour la partie graphique de la documentation, plus exactement pour son élaboration.

Le besoin d'unification de la documentation graphique est toujours présent dans les rangs des restaurateurs. Cet essai ou plutôt cette proposition fait aussi partie des aspirations visant à la modernisation et à l'unification, en mettant l'accent sur l'emploi des symboles graphiques dans la documentation de nos interventions.

Dans la documentation graphique, les restaurateurs utilisent de nos jours trois formes ou modes de base:

- les ombres et les hachures,
- l'utilisation de couleurs différentes et
- l'utilisation de symboles (dans des cas rares).

Aucun des modes indiqués n'est prépondérant et unifié; c'est pourquoi pour l'explication on se sert encore de légendes. Bien sûr, un tel mode non unitaire est mauvais. Il faut toujours d'abord étudier la légende et après seulement on peut se plonger dans les problèmes professionnels que l'on veut expliquer à l'aide du dessin documentaire.

Surtout le mode des couleurs a l'inconvénient qu'avec les moyens d'aujourd'hui il est difficile de le multiplier à bon marché. De plus, l'échelle des couleurs est trop petite pour ces besoins.

J'estime que ce problème est presque équivalent à celui de la terminologie professionnelle unifiée que certes résolvent plusieurs groupes dans les différentes parties du monde, mais avec le même résultat. La terminologie est toujours telle qu'elle était. Les données des

documentations professionnelles sont traitées aussi à l'ordinateur, mais elles ne sont pas applicables dans une étendue plus vaste, précisément à cause du caractère non unitaire de la terminologie et aussi de l'élaboration de la documentation graphique.

En 1975 j'ai publié dans notre revue professionnelle un article, dans lequel j'ai essayé de résoudre la problématique des symboles unifiés (LA PROTECTION DES MONUMENTS, XVII-XIX/2, pages 69-74). En 1977 j'ai participé à une consultation sur la problématique des peintures murales, qui s'est tenue à Suceava (Roumanie) et qui a été organisée par "ICOMOS" et les Services des monuments de la Roumanie. Parmi les rapports il y avait aussi l'exposé du collègue Matei Lazarescu "Elaboration de la documentation des travaux de restauration - Suggestions pour une méthodologie unitaire", qui traite des mêmes problèmes. Sans nul doute, ces problèmes affectent nombre d'entre nous.

La raison fondamentale pour l'emploi unifié des symboles graphiques réside dans la compréhension plus facile de la documentation graphique des interventions de restauration, sans utilisation des instructions - légendes employées jusqu'à présent. Evidemment, ce faisant, nous rencontrerons une série de difficultés qui ont déjà freiné les efforts déployés jusqu'ici pour la solution de cette problématique. J'estime qu'il est indispensable de chercher les points de départ de base, qui limiteront le nombre des symboles à un nombre raisonnable. En outre, il faudra traiter séparément la documentation de l'état d'un ouvrage avant l'intervention et la documentation de tous les processus en cours d'intervention. On peut se décider à employer les symboles pour les deux ensembles ou bien seulement pour la documentation des processus. L'utilisation pour les deux ensembles serait conforme.

Des états ou les processus rares, exceptionnels ou spécifiques de quelque autre manière que ce soit seraient, à l'avenir aussi, décrits individuellement.

Pour nos besoins il faudrait réellement un bon nombre de symboles, mais j'estime qu'on pourrait s'y habituer relativement vite et les comprendre. La géographie, la chimie, la météorologie et bien d'autres domaines encore connaissent également l'utilisation des symboles que les spécialistes de ces domaines connaissent et comprennent entièrement.

L'introduction des symboles dans notre documentation signifierait un grand progrès, car la littérature aussi serait plusieurs fois munie d'une telle documentation et elle atteindrait un bien plus grand effet que le texte seul.

Nous devrions nous efforcer d'obtenir le plus tôt possible une proposition - définitivement élaborée et applicable dans la pratique - des symboles graphiques, qui satisferait au moins à quelques-unes des exigences citées:

- que déjà par la forme ils fassent pressentir l'état ou le processus qu'ils désirent illustrer,
- qu'ils soient lisibles même à la superposition de quelques signes (il ne sera jamais possible d'utiliser tous les signes sur un exemple de la documentation; c'est pourquoi il faudra présenter l'état ou les processus à l'avenir aussi sur plusieurs feuilles à la fois),
- qu'il soit possible de les utiliser sous forme imprimée sur une feuille (système "1 traset") et
- qu'ils ne ressemblent pas trop aux lettres ou aux chiffres.

Comme exemple j'indique quelques solutions possibles :

- 1 - on désignerait linéairement les différentes périodes de temps ou couches. De cette manière on peut désigner 6 périodes ou couches successives.

- 1.1 - la période ou couche
la plus ancienne



- 1.2 - la deuxième période ou couche



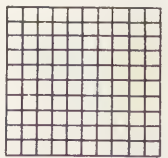
- 1.3 - la troisième période ou couche



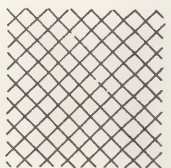
- 1.4 - la quatrième période ou couche



- 1.5 - la cinquième période ou couche



- 1.6 - la sixième période ou couche

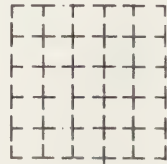


- 2 - L'état des dégradations et des altérations avant l'intervention serait déjà illustré à l'aide des symboles.

2.1 - domaine humide (ou domaine d'humidité)



2.2 - domaine de dessalement



2.3 - boursoufflage (domaines creux)



2.4 - écaillage (détachement de la couche)



2.5 - micro (flore), micro (faune)

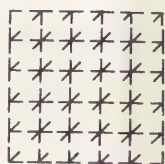


- 3 - A l'aide des symboles on illustrerait aussi (presque) tous les processus en cours de restauration.

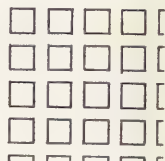
Au point 3.5, on inscrit dans un cercle la lettre R (ancienne retouche, RC (ancienne reconstruction), RN (nouvelle retouche) ou RCN (nouvelle reconstruction),...

On désignerait par une surface noire les dégradations expressives de la polychromie dans les sculptures ou de la couche de couleur dans les peintures.

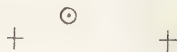
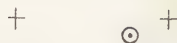
3.1 - écartement du sel



3.2 - consolidation



3.3 - injection



3.4 - écartement d'une couche
(détachement)



3.5 - traitement final de la surface
(retouches, reconstructions ...)



Comme essai on vérifie encore la possibilité de la superposition des symboles.

Figure A.Etat avant la restauration.

Figure B.Documentation des processus en cours de restauration.

Figure C.Etat après la restauration (le tout dessiné par I. Bogovčič).



FIGURE A



FIGURE B



FIGURE C

ETABLISSEMENT DEFINITIF ET MISE EN
APPLICATION DU PLAN DE CLASSEMENT DE LA
DOCUMENTATION DU SERVICE DE LA RESTAURATION
DES PEINTURES DES MUSEES NATIONAUX

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Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981

Groupe de travail: Documentation

ETABLISSEMENT DEFINITIF ET MISE EN APPLICATION DU PLAN
DE CLASSEMENT DE LA DOCUMENTATION DU SERVICE DE LA
RESTAURATION DES PEINTURES DES MUSEES NATIONAUX

E. Pacoud-Reme et A. Lautraite

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75001 Paris
France

Résumé : Le classement "matière" de la documentation présenté en 1978 a été modifié en tenant compte des impératifs apparus ces trois dernières années. Pour les besoins du service, le codage des documents a été commencé, en priorité, par les kodachromes et les livres et revues. Les remaniements et adjonctions du contenu même du thésaurus sont le reflet des mouvements de tableaux dans notre atelier. L'aspect "Peinture murale" a été développé, et un classement historique et géographique de la documentation a été mis sur pied, parallèlement au classement matière.

-:-:-

En 1977, un thésaurus thématique destiné au classement de la documentation écrite et photographique a été mis sur pied au S.R.P.M.N. ; il a fait l'objet d'une communication à la Cinquième Réunion Triennale du Comité pour la conservation de l'I.C.O.M., à Zagreb, en 1978.

Trois ans après, il nous a paru intéressant de faire connaître les problèmes qui se sont posés lors de sa mise en application, et de la mise à jour que nous avons été conduit à y apporter.

Au delà des problèmes matériels, qui ont déterminé certaines priorités dans le codage des documents, des questions au niveau du contenu même du thésaurus, ainsi que de nouvelles données nous ont amené à remanier profondément certains aspects. Par ailleurs, le développement de celui de la peinture murale est en cours d'étude. Enfin, un autre type de classement, historique et géographique, a été établi parallèlement.

Les problèmes matériels :

Il convient tout d'abord de rappeler la quantité de documents à classer : outre les livres et revues spécialisés en restauration, la documentation écrite comporte des "archives", manuscrits ou imprimés isolés d'origine diverses, et des rapports de restauration (2000 environ). La documentation photographique comprend 13.000 Kodachromes, 30.000 Noir et Blanc, une ancienne collection d'autochromes, quelques ektachromes et tirages couleurs sur papier. L'augmentation de cette documentation se fait à un rythme de plus en plus rapide.

Le personnel formé aux problèmes de restauration, capable de lire les documents, n'étant pas disponible à plein temps pour leur codage, nous aurions pu choisir d'éviter l'intégration dans le classement de tout le fond existant, mais seulement de commencer à classer la documentation au fur et à mesure de son développement à partir d'une date donnée.

Nous avons préféré privilégier le classement de certains types de documents, choisis en fonction de deux directions :

- l'exploitation à des fins pédagogiques (cours et expositions dont le service est chargé)
- l'exploitation en vue de publications, reflets de notre activité quotidienne.

Ainsi, le classement des livres et revues d'utilisation courante s'est effectué sans difficultés majeures en quatre mois. Par contre les "Archives" et les rapports, d'usages plus ponctuels, restent à coder.

En ce qui concerne la documentation photographique, les kodachromes ont été privilégiés pour leur utilisation très fréquente. Leur codage est actuellement bien avancé.

Les modifications du contenu du thésaurus :

Elles sont de deux types :

- des adjonctions de nouveaux termes, ou parfois des changements de termes, qui n'affectent pas la hiérarchie précédemment établie

- des remaniements plus profonds, qui remettent en cause la hiérarchie tout en permettant de nombreuses adjonctions de termes. Ce type de modifications a été surtout nécessaire pour l'aspect "Couche Picturale".

Ces modifications ont plusieurs causes :

- le premier choix de mots directeurs s'est révélé, en particulier au cours du codage des kodachromes, souvent trop abstrait, théorique, n'exprimant pas directement la réalité des documents. Ainsi, certains phénomènes, décrits dans la documentation écrite, visibles sur nos documents photographiques, mais non expliqués scientifiquement à l'heure actuelle, ont pu trouver leur place.

- les modifications intervenues sont le reflet de l'expérience quotidienne du travail de notre atelier, et des questions qui se posent pour chaque tableau qui y passe. C'est ainsi que lors de l'élaboration du thésaurus, nous avons essentiellement à l'esprit les tableaux de la collection Campana, tous primitifs italiens dont nous venions de terminer la restauration systématique.

Depuis 1977, les tableaux traités par le S.R.P.M.N. se sont beaucoup diversifiés, et notre documentation s'est enrichie d'éléments significatifs de toutes les époques, qu'il a fallu intégrer à notre classement. Cette diversification importante permet de penser à l'heure actuelle, que la mise à jour du thésaurus, qui garde un caractère permanent, n'y apportera plus cependant de modifications profondes.

Le développement du système de classement à la peinture murale et la création d'un système de classement parallèle :

Le service est, depuis quelques années plus souvent chargé de la restauration de peintures murales (fresques et autres techniques). Il a donc fallu envisager de développer, l'aspect du thésaurus spécifique à ce domaine, afin de pouvoir classer cette nouvelle documentation. La publication du livre de Mrs. PHILIPPOT et MORA⁽¹⁾ nous a grandement encouragé dans cette voie. Ce travail, encore en cours, doit être présenté à des personnalités faisant autorité sur le plan international avant d'être définitif.

Enfin, un classement qui permet l'approche historique et géographique de la documentation, a été établi parallèlement au classement matière. Il facilite l'information des restaurateurs à la recherche de ce qui a déjà été fait dans notre atelier, en France ou à l'étranger, sur des tableaux de mêmes écoles ou de mêmes peintres que ceux sur lesquels ils travaillent. Il permet également, par recoupements avec le classement

matière, de procéder à des rapprochements statistiques intéressants.

Ce classement historique et géographique est très proche de celui utilisé par la Documentation du Département des Peintures du Louvre, ce qui rend plus aisée l'étude d'un tableau à la fois sous l'angle de l'histoire de l'art et sous l'angle de la Restauration.

Il existait déjà partiellement pour la documentation photographique, et l'accent a donc été mis d'abord sur la documentation écrite, lors du codage.

Placé en annexe à la fin de notre plan de classement, il adopte le même type de numérotation. Ainsi la première lettre (H, pour Histoire) est comme ailleurs un procédé mnémotechnique.

Nous en montrons ici une partie à titre indicatif :

CLASSEMENT HISTORIQUE ET GEOGRAPHIQUE

HA.Art et Archéologie Antique

- HA 0. Egypte
- HA 1. Moyen Orient
- HA 2. Grèce et Rome

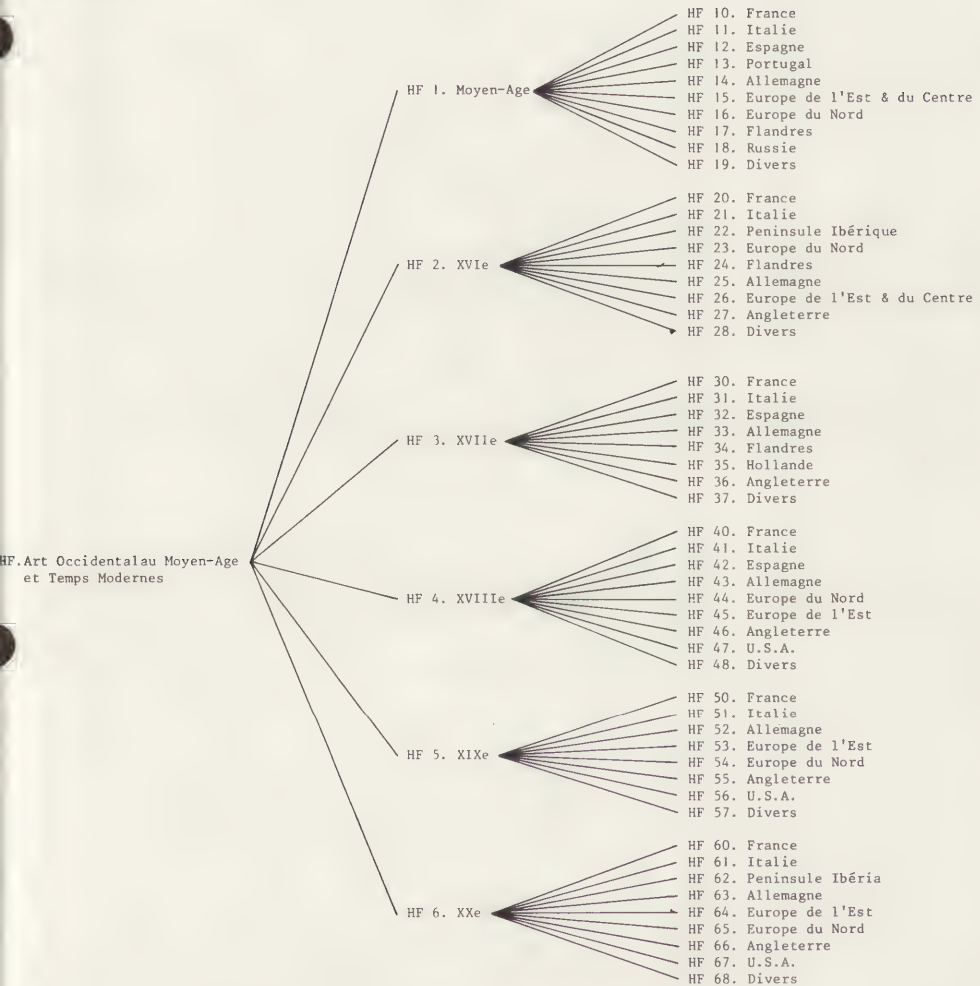
HB.Art et Ethnologie Africains

HC.Art et Ethnologie des Amériques

- HE 1. Sud
- HE 2. Nord

HD.Art de l'Extrême-Orient

HE.Art de Byzance



Sous chaque numéro, les documents sont classés par ordre alphabétique d'auteurs, et des titres des oeuvres, ordre alphabétique en conformité avec les normes de l'Association Française de Normalisation (A.F.N.O.R.) (2).

On peut donc constater que l'établissement définitif et la mise en application de l'ensemble de ce plan de classement, ont été guidé par les besoins réels du service, dans ses différentes activités. A travers un fond documentaire sans cesse augmenté et diversifié en fonction des tableaux traités par le service, sa création et son évolution témoignent de la vie quotidienne d'un atelier.

Notes : (1) PHILIPPOT P. , MORA P. et L. :
La Conservation des Peintures Murales ,
Editrice Compositori , Bologne 1977.

(2) A.F.N.O.R., norme NF Z 44-0001, de Mai 1969,
et fascicule de documentation FD Z 44-062
de Juillet 1963.

POLYCHROMED SCULPTURE

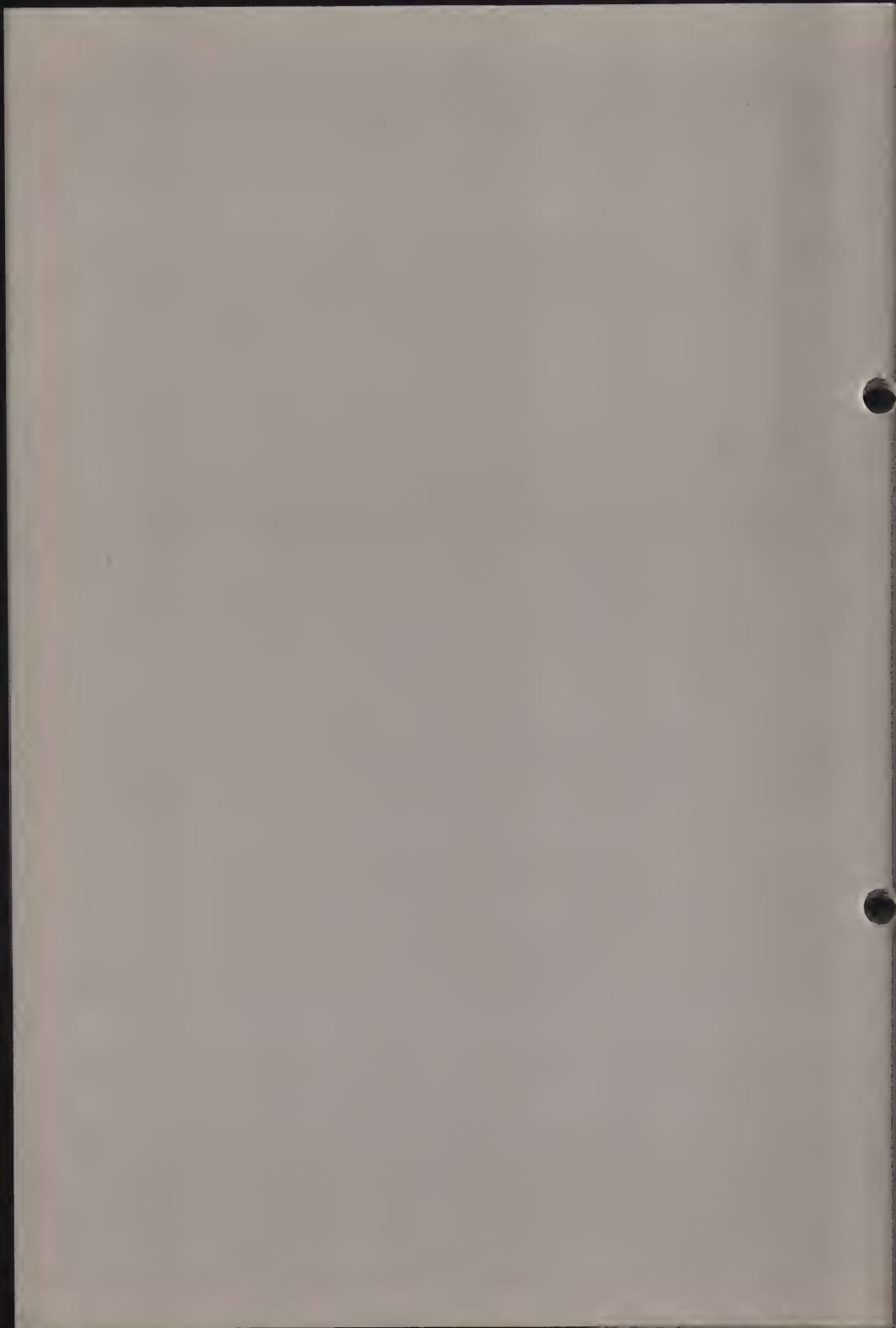
Coordinator : P. Philippot (Belgium)

Assistant coordinator: A. Ballestrem (FRG)

Members : R. Guilly (France)
 Mr Hückel (FRG)
 M. Koller (Austria)
 L. Lelekov (USSR)
 A. Recchiuto Genevese (Spain)
 M. Serck-Dewaide (Belgium)
 J.R.J. van Asperen de Boer (Netherlands)

Programme 1978-1981

1. Mettre à jour la bibliographie de la sculpture polychrome (Serck-Dewaide).
2. Suggérer une contribution française sur quelques examens technologiques détaillés de sculptures polychromes de provenance française (Guilly).
3. Suggérer une contribution mexicaine sur le thème de l'intervention minima pour la conservation et la présentation de pièce.
4. Suggérer un rapport péruvien ou brésilien ou mexicain sur un ensemble intérieur du 17^{me} ou 18^{me} s. - retables, chair de verité, confessionaux, lambris, orgues et peintures et peintures murales - avec ses problèmes de conservation.
5. Suggérer aux canadiens de présenter le phénomène de la sculpture (?) indienne et l'emploi de la couleur
 - a) examen de la signification de la couleur et des traces d'utilisation de l'objet
 - b) examen technologique.
6. La conservation de sarcophage égyptien au Metropolitan Museum à New York (Hückel, L.F.P. München).
7. Le Japon (problèmes de conservation et techniques).
8. Sculptures en pierre polychrome.
9. Rapports sur les problèmes de conservation de sculpture et politique de solutions à adopter.



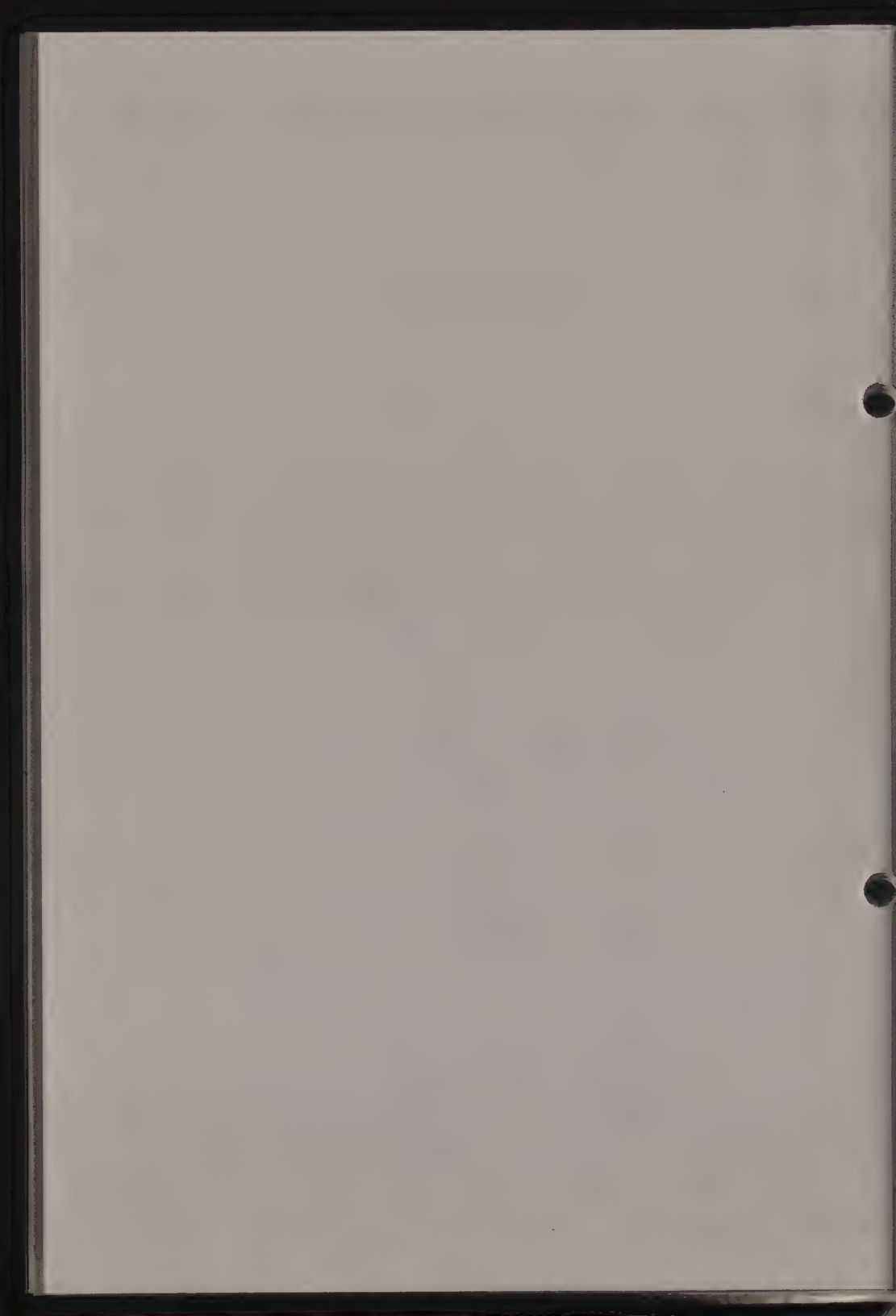
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CONSERVATION D'OBJETS DE L'EGYPTE ANCIENNE
EN BOIS POLYCHROME AU MUSEE DE L'ERMITAGE
D'ETAT

Julie Natchinkina et Eugenie Cheinina

Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981

Groupe de travail: Sculpture polychrome



CONSERVATION D'OBJETS DE L'EGYPTE ANCIENNE EN BOIS
POLYCHROME AU MUSEE DE L'ERMITAGE D'ETAT

Julie Natchinkina et Eugenie Cheinina

Musée de l'Ermitage d'Etat
191065 Leningrad
USSR

Résumé

Dans cet exposé on traite de la méthode de conservation des sarcophages en bois polychrome, de stèles, de caissettes pour figurines funéraires, de sculptures de l'Egypte ancienne à l'aide de solutions de polymères synthétiques et de mélanges de cire-résine ainsi que des procédés de nettoyage des recouvrements anciens de restauration.

Les travaux de restauration ont été poursuivis au Laboratoire de restauration de la peinture monumentale de l'Ermitage d'Etat.

Les objets de l'Egypte ancienne en bois polychrome occupent une place importante dans la collection des oeuvres de culture et d'art de l'Egypte ancienne. Ce sont des sarcophages, des caissettes pour les figurines funéraires, des stèles, des statuettes.

La restauration de cette collection a été commencés dans le Laboratoire de la peinture monumentale à la fin des années cinquante sous la direction du fondateur du Laboratoire P.I.Kostrov.

Les difficultés de la restauration de ces objets deviennent évidentes si on prend en considération que chaque objet présente tout un complexe de matériaux aux différentes propriétés physiques et chimiques: support en bois, préparation beige (de loess) parfois un tissu, couche de fond à base de colle et de miel, couche picturale au liant de colle et de détrempe.

Il faut aussi ajouter la présence de nombreuses couches différentes par la composition et par le caractère, des collages et des suppléments - colles aqueuses, vernis à l'alcool, cire, colophane, gypse, - faits lors des restaurations avant que les objets soient entrés à l'Ermitage.

L'endommagement de tous ces matériaux, lié au processus du vieillissement et des actions extérieures ont un caractère très différent.

La détérioration du support en bois est provoquée par le changement de volume du bois sous l'influence des fluctuations de l'humidité et de la température. Avant tout cela s'est manifesté aux endroits de jointures du bois, surtout dans les endroits de jonction des pièces où les fibres de bois ont une direction différente. Des ruptures et des disjonctions ont lieu comme sur de grands sarcophages (mesurant 1,8 - 2,4 m de long) faits de grosses planches (4-12 cm) et joints à l'aide de tenons et de chevilles, ainsi que sur de petites statuettes, dont certains détails étaient taillés à part et aussi attachés à l'aide de tenons. On peut observer la déformation des planches, de nombreuses fissures passant de part en part, le détachement ou l'écaillement de minces plaques de bois. Les pièces entières de bois, qui forment les parties principales d'une statuette, ont de profondes fissures radiales aux bords écartés. Les détériorations provoquées par les insectes étaient rares.

L'altération des couches posées sur le support en bois est provoquée habituellement par la différence du mouvement du bois et de ses couches. Ainsi la préparation beige (son épaisseur est de 1 à 30 mm), égalisant les planches grossièrement travaillées du sarcophage et des caissettes, cachant les défauts du bois et les endroits des joints, précisant les formes anthropoïdes du sarcophage s'est fendue et s'est considérablement émietlée. Le fond à base de colle et de miel (épaisseur 0,5 - 5 mm) couvrant la préparation beige ou bien directement le bois, a l'aspect poudreux, son adhésion s'affaiblit et il se détache du support.

Sur certains sarcophages et plus rarement sur les statuettes la préparation beige ou la couche du fond sont recouvertes d'un tissu par-dessus lequel il y a une couche de fond.

Dans les endroits détériorés on peut voir que le tissu

n'a presque plus de résistance. Parfois ce tissu s'écaille et se détache du support avec la couche du fond et la couche picturale.

La peinture des objets nommés ci-dessus est exécutée à base d'un liant de colle et de détrempe, dans la plupart des cas sur la couche du fond, mais parfois aussi sur le support-même. On peut parfois rencontrer les deux procédés d'application de la peinture sur le même objet. Les pigments - bruns, rouges, jaunes (ferriques), noirs (charbon), blancs (craie, gypse). Toutes les couleurs sont finement broyées, excepté la bleue, plus rarement la verte - la fritte à gros grains.

La détérioration de la couche picturale a des causes différentes: l'altération des couches inférieures, le vieillissement du liant de la peinture ainsi que les anciens recouvrements des restaurations antérieures. Les détériorations les plus caractéristiques de la couche picturale sont: l'état poudreux, le détachement de la poudre, un réseau de craquelures et de différentes fissures, parfois au bords relevés, le détachement du fond.

Différents recouvrements lors des travaux de restauration ont provoqué une altération considérable de couleurs. Ce sont surtout les tons bleus exécutés en fritte à gros grains qui ont été atteints. L'adhésion de la fritte et du support est beaucoup plus faible que celle des autres pigments; il s'en suit que la fritte a subi beaucoup plus de collages et est devenue presque partout brune-foncée ou presque noire. Les rouges, les jaunes et les blancs ont aussi jauni et sont devenus plus foncés sur plusieurs objets. La peinture porte des surpeints tardifs. La surface des sarcophages est couverte de nombreuses taches, coulées, recouvrements (surtout les parties intérieures de la caisse) et aussi de poussière, de suie etc.

Excepté les couches de nature différente couvrant la surface des sarcophages et les caissettes pour les figurines funéraires on trouve aussi des fixations et des suppléments de restauration. A son époque les restaurations ont joué un rôle positif dans la conservation des objets, mais cependant plus tard sont devenues la cause de détériorations ultérieures. Ainsi les remplissages en gypse des fissures de joints, le collage à l'aide des colles solides et rigides de lacunes et aussi les jonctions à clous ont provoqué de sérieuses détériorations dans plusieurs monuments. Les lacunes bouchées avec des pièces de bois et le parquetage des caisses de sarcophages soigneusement exécutés subissent très peu d'altérations.

Ainsi les particularités des matériaux du monument, les matériaux des suppléments anciens, le degré et le caractère de la détérioration de chacun d'eux déterminaient le problème du traitement. Par conséquent, le

complexe du traitement devait comporter la consolidation de la peinture, du support et de la préparation beige, l'adhésion entre eux et avec le support en bois qui à son tour exigeait d'être consolidé. Il était aussi indispensable d'éliminer les couches supérieures et les suppléments anciens qui altéraient la peinture et qui pourraient être la cause de la détérioration ultérieure du monument.

L'action de l'eau sur la peinture et les supports, la déformation et l'hygroscopicité du bois faisaient indésirable l'utilisation de colles aqueuses et de dispersions. C'est la raison pour laquelle on a utilisé la méthode de consolidation combinée en employant la solution des polymères synthétiques dans des solvants organiques et des compositions de cire et de résine. Pour la consolidation des couches affaiblies de peinture, de support, de préparation beige et de certaines parties de bois nous avons utilisé les solutions de polybutylmétacrylate à basse viscosité (PBMA). Le collage des couches supérieures après l'imprégnation était réalisé avec le mélange de cire-résine.

Le polybutylmétacrylate à basse viscosité (avec la viscosité spécifique de 1% de solution de toluol 0,2 - 0,3) a toutes les qualités nécessaires d'un matériau de restauration, se dissout dans des solvants organiques de plusieurs classes, en formant des solutions, assurant différents moyens de consolidation: imprégnation, consolidation superficielle, collage. La consolidation avec PBMA est réversible. Grâce à ces qualités PBMA est largement utilisé durant trente années au Laboratoire de peinture monumentale de l'Ermitage d'Etat pour la conservation de différents monuments. Les mélanges cire-résine ont une haute stabilité de longue durée, une résistance aux facteurs biologiques, une adhésion suffisante au bois, un retrait insignifiant; dans le mélange avec un remplissage devient un matériau durable pour boucher les cavités, les fissures et les petites lacunes.

Les matériaux cités donnent la possibilité d'éviter l'utilisation de dispersions aqueuses qui sont employées dans plusieurs laboratoires.

Les travaux de traitement sont précédés d'un examen méticuleux du monument pour établir le caractère et le degré de la détérioration et pour mettre en évidence la présence des surpeints et des altérations. Un examen visuel et microscopique s'effectue ensemble avec un examen aux rayons UV et IR. A part cela les laboratoires chimiques et physiques de l'Ermitage d'Etat déterminent les pigments, les liants de la couche picturale et des supports et la composition des recouvrements de restaurations.

Se basant sur les données reçues et prenant en considération les particularités de chaque monument, par

voie d'essai on met au point les procédés d'élimination superficielle et les recouvrements anciens, on détermine le régime de l'impregnation et du séchage, la concentration des solutions et la quantité nécessaire de polymères ainsi que la suite des opérations.

En commençant le traitement on élimine tout d'abord le danger de la destruction des endroits détériorés de la surface. On les consolide et on les colle avec des solutions d'acétone de PBMA (8-12%). Ensuite, en cas de nécessité, on consolide les endroits les plus pulvérisés du support avec la même solution, mais de moindre concentration. Assurant ainsi la possibilité du traitement du monument on procède à la consolidation.

Pour la consolidation totale on utilise les solutions de xylol de PBMA (10-15%). On applique la solution avec un pinceau à mesure d'absorption (6-10 fois). La mise de l'objet dans une chambre saturée de vapeurs du solvant (xylol) contribue à l'absorption plus intense de la solution. Le séchage ralenti qui suit garantit une repartition régulière du polymère dans l'épaisseur du matériau consolidé. Certains endroits de bois fortement réduits en poudre sont aussi consolidés par les solutions de xylol de PBMA. A cette opération il n'y a pas de danger d'écaillage car il n'existe pas de limite fortement prononcée entre les couches de bois consolidées et nonconsolidées.

La couche picturale et le support consolidés par l'impregnation à cœur dans les endroits d'exfoliation sont collés à l'aide des solutions d'acétone de PBMA. On emploie les mêmes solutions pour coller les fissures et les bords des lacunes.

Au cas où la couche picturale couvre à même le support en bois (sans la couche de fond) il suffit de procéder à la consolidation avec les solutions d'acétone de PBMA. Cependant on trouve sur certaines caisses de sarcophages des couches superposées et des collages. C'est pourquoi pour éviter l'apparition des taches sur la peinture il faut choisir des solvants qui n'agiraient pas sur les collages, ou bien utiliser les solutions alcooliques de polyvinylbutyral.

Consolidées avec la solution de PBMA les couches du fond avec la couche picturale sont fixées au support en bois avec le mélange de cire blanchie et de résine dammar qu'on introduit à l'état fondu. En repassant doucement et en appuyant légèrement avec un instrument réchauffé le mélange se repartit dans la cavité, remplit les fissures du bois. Ainsi on élimine partiellement la déformation des couches posées sur le support en bois. Au cas où le retrait du bois est considérable et de grandes cavités se sont formées il faut pour fixer les couches superposées au support de bois ajouter dans le mélange de cire-résine un remplissage - le loess.

Pour l'assemblage de différentes parties du support en bois on utilise l'ancien procédé de fixation avec les détails en bois - chevilles, tenons, en utilisant ou possible les anciens qui sont solides, ou en les remplaçant par de nouveaux. Les parties de bois déformées et disjointes sont jointes en évitant trop d'efforts en les serrant et en remplissant les larges fissures et ruptures du mélange de cire et de colophane (1:1). La solidité de ce mélange ne dépasse pas la solidité du bois assemblé, n'empêche pas le mouvement des couches de bois et ne provoque pas de déformation. Sur les objets où les joints de planches étaient remplis de préparation beige (sarcophages, caissettes pour figurines funéraires) les endroits où il y a des lacunes de préparation beige, on les remplit du mélange de cire et de colophane avec un remplissage - coton: de petite tampons de coton imbibés de ce mélange chaud sont introduits avec des pincettes dans les fissures.

Pour enlever la charge des parties affaiblies du bois (p.ex. couvercles des grands sarcophages en position verticale) on utilise des montages doubles - des carcasses qu'on joint avec les planches du sarcophage à l'aide de chevilles en bois. Pour fixer les planches des caisses on utilise le parquetage. Les suppléments en gypse des restaurations sont remplacés par ceux de bois; s'il est impossible de les éliminer on les imprègne de la solution PBMA pour réduire l'hygroscopicité du gypse.

L'élimination des recouvrements anciens, altérant la peinture est l'un des problèmes importants de la restauration des monuments examinés. La place que le processus de nettoyage occupe dans le processus du traitement, les matériaux utilisés et les procédés dépendent du caractère et du degré de conservation de la couche picturale, de la couche du fond, de la nature et de la densité des recouvrements qu'il faut éliminer.

Comme il a été dit plus haut, les recouvrements tardifs présentent généralement des colles aqueuses du type de colles de miel ainsi que des vernis à l'alcool. Le nettoyage consiste en l'action des solvants correspondants et en l'élimination de la substance amollie avec un pinceau, un scalpel, des tampons, des compresses ou avec du papier à filtrer. Ce qui est le plus compliqué c'est l'élimination des colles aqueuses parce qu'elles sont posées sur les couches de la peinture et du fond soumises à l'action de l'eau. Dans certains cas ce n'est que la consolidation préalable de la couche picturale et du fond avec la solution de polymères qui permet le nettoyage. Le plus souvent c'est la fritte à gros grains qui exige la consolidation dont le nettoyage est le plus

effectif quand on procède à maintes humidifications suivies d'application du papier à filtrer. La consolidation préalable se fait avec la solution (2-3%) de PBMA dans l'acétone ou bien de PVB dans l'alcool. x)

Au cas où on procède au nettoyage après la consolidation totale de l'objet, les couches de saleté supérieures et différents recouvrements de colle sont de même consolidés par PBMA. C'est pourquoi avant de procéder au nettoyage on diminue la quantité du consolidant à mesure qu'on puisse réaliser l'élimination de colles aqueuses. Le réglage de quantité de l'adhésif se fait à l'aide de l'action de l'acétone ou du méthylethylcétone (avec un pinceau, ou appliquant une compresse), ou avec la vapeur du xylol.

Comme suite du processus du nettoyage le coloris de la peinture et la relation des tons revivent. Surtout cela se manifeste sur les tons bleus qui sont le plus exposés aux altérations et aux fortes encollures. La dernière étape du traitement de la couche picturale et de la couche du fond consiste à boucher les lacunes et les fissures à l'aide du mastic à loess mélangé avec les solutions de résine (solution d'acétone de PBMA ou de la solution d'alcool -PVB). On recouvre aussi de ce mastic la surface des fissures et des lacunes qui étaient bouchées à l'aide du mélange de cire-résine. D'une part la mastication est un procédé complémentaire de consolidation, d'autre part elle fait les lacunes et les fissures moins visibles. En mélangeant le loess avec les solutions de PBMA ou de PVB de concentrations différentes on peut trouver un ton neutre et une texture du mastic qui peut remplacer la tonalite.

La méthode de restauration des objets en bois polychrome de l'Egypte ancienne exposée dans cet article, fondée sur l'utilisation de polymères synthétiques et de compositions de cire-résine, permet d'arrêter la détérioration du monument, d'éliminer les couches étrangères et d'assurer sa conservation ultérieure. C'est cette méthode qui a été utilisée à l'Ermitage pour le traitement de plusieurs grands sarcophages. Parmi ces sarcophages il y en a deux de forme anthropoïde du prêtre Pet-Isi (X-me siècle a.n.e., dimension extérieure 240 100 cm) ou toutes les espèces de détérioration avaient lieu. On a réussi à mener à bien le traitement du sarcophage Baba (X-me siècle a.n.e. 180 50) ou la couche picturale avec le fond et le tissu se détachaient totalement du fond de la caisse.

De même on a mené à bien la conservation du sarcophage du prêtre Pa-Kesch (X-me siècle a.n.e. 265 65 cm) surtout le nettoyage de la couche picturale du fond intérieur de la caisse posée directement sur le support en bois sans couche de fond. Ce qui présente

x) PVB - polyvinylbutyral

un intérêt tout particulier c'est le traitement du sarcophage A-ta (XX-me siècle a.n.e. 188 48 45 cm) où après le nettoyage de la couche picturale et l'élimination d'anciennes encollures on a réussi à restituer le coloris de la peinture ou comme il s'est avéré prédominait la couleur bleue et non pas la couleur noirebrune qu'il y avait avant le traitement. On a aussi réussi à restaurer la peinture de plusieurs caissettes funéraires. Il était particulièrement difficile de nettoyer et de conserver la peinture d'une stèle (X-me siècle a.n.e. 50x30cm.) dont le bois était tout délabré et vermoulu; quant à la peinture, elle se trouvait sur une couche épaisse de fond en poudre. Parmi beaucoup de sculptures restaurées la plus difficile à cause du bois délabré était le groupe nommé "Brasserie" comportant 12 figurines posées sur le même fondement (XXI-me siècle a.n.e. 65x17 cm.) Il est aussi à noter la restauration d'une cuillère à toilette (XV siècle a.n.e. 15 cm.) où la couche supérieure du bois délabré était soulevée par des cristaux de sel.

La restauration a été réalisée par les collaborateurs du Laboratoire de la peinture monumentale: P.I.Kostrov, E.G.Cheinina, M.P.Vinokourova, T.V.Kovalenko, L.P.Gaguene, J.J.Natchinkina, R.M.Beliaeva, T.S.Vassilenko, A.M.Bliakher, E.S.Kalmikov, T.P.Ter-Oganian.

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EXPERIENCE DE RESTAURATION DE STATUETTES
PEINTES DE TANAGRA DU 3EME SIECLE AVANT
NOTRE ERE DE LA COLLECTION DE L'ERMITAGE
D'ETAT

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Comité pour la conservation de l'ICOM
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Groupe de travail: Sculpture polychrome

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Résumé

Dans l'exposé il s'agit de l'examen et de la restauration d'une grande partie de statuettes en terre cuite peinte de Tanagra du III-e siècle a.n.è. reçues par le Laboratoire de Restauration des peintures murales en 1979.

Un examen visuel et détaillé et les résultats des analyses microchimiques faites au Laboratoire de chimie de l'Ermitage ont permis de préciser la technique et certaines étapes du processus technologique de la création des statuettes, de choisir les procédés de restauration et de nettoyage. Il est indiqué que la méthode de restauration élaborée à cette intention pour consolider la peinture en encaustique ancienne sur un support poreux est rationnelle.

L'Ermitage possède une grande collection de terre cuites peintes de Tanagra de l'époque hellénique.

Ces oeuvres d'art plastique de premier ordre de Grèce qui se trouvaient depuis un siècle dans les collections de l'Ermitage ont été soumises à un examen détaillé en but de restauration. Parmi les différentes terre cuites reçues par le Laboratoire de restauration de la peinture monumentale prédominent les figurines de femmes drapées (leur hauteur ne dépasse pas 20-30cm). Il faut signaler comme exemple les échantillons les plus caractéristiques à en juger d'après leur état de conservation: "Femme assise au diptique", "Femme debout à l'éventail", "Muse de la comédie", "Aphrodite et Eros", "Tête de femme", "Jeunes filles jouant", "Deux amies".

L'examen visuel a établi que la céramique des statuettes s'écaille et a des craquelures, dues à des causes différentes: vieux endommagements mécaniques et changement de température et d'humidité. Les bases de "Deux amies" et de la "Femme debout à l'éventail" ont été collées jadis avec des colles différentes qui n'étaient pas solides et qui ont laissé des traînées et des taches sur la couche picturale. De pareilles traces d'anciennes restaurations se trouvent sur presque toutes les statuettes. Les colles solubles dans de l'eau ont perdu leur élasticité et sont devenues la cause de la détérioration de la couche picturale, des craquelures, de l'écaillage et de la pulvérisation. La statuette "La muse de la comédie" a été reçue disjointe.

L'examen microchimique de la matière argileuse a montré que son contenu comprend 48% d'ocre et de carbonate et 52% d'argile parsemée de sable. La porosité de la céramique étant mesurée à l'aide du xylol a indiqué 46%. La céramique a été soumise à une faible cuisson.

Les statuettes sont couvertes d'une préparation ayant l'épaisseur à partir des fractions d'un millimètre dans les creux du modelé. On a observé un certain détachement de la préparation du support, une friabilité surtout dans les couches épaisses. On a découvert de la cire, de la résine naturelle dans la composition de la préparation; la craie et la caolin servaient de remplissage. Jusqu'à présent on était de l'avis que les statuettes étaient recouvertes d'engobe avant la cuisson. Les données des analyses chimiques de la préparation donnent la possibilité de faire la conclusion que la préparation était appliquée après la cuisson, car le contenu de la préparation (craie, cire, résine) n'est pas capable d'être soumis à des températures

élevées. En même temps on peut corriger l'emploi du terme "engobe" qu'on utilise souvent pour indiquer la préparation des terre cuites de Tanagra. Ce terme sousentend la couche d'argile claire lévignée qui ne prend pas la couleur rouge à la cuisson et qui mélangée avec de l'eau afin d'avoir la consistance de crème, recouvre le récipient avant le séchage.

Les statuettes examinées ont une préparation de craie mélangée avec un agglutinant de cire-colle appliqué sur la céramique. Cette préparation se distingue considérablement de l'engobe.

La couche picturale est lustrée, affaiblie et partiellement perdue (surtout dans les endroits saillants), sa surface est friable en plusieurs endroits. L'examen au microscope a montré que souvent les couches picturales se superposent. Ainsi le manteau de la "Femme assise au diptique" était couvert d'une couleur rose et plus tard recouvert de couleur bleue. Les yeux sont peints de couleur bleu-claire (évidemment de smalte) et par-dessus la couleur bleue blanche (se détermine visuellement comme outremer avec du blanc).

La couche inférieure de la coiffure est rouge recouverte de brun autour du visage. Il est possible que la présence de plusieurs couches aperçues sur de nombreuses statuettes est la cause de l'écaillement et de la détérioration de la couche supérieure.

Les statuettes sont peintes avec des couleurs qui sont caractéristiques à l'art des statuettes de Tanagra. Ce sont les couleurs rouge (ocre et cinabre), bleue (smalte, outremer), différentes nuances de l'ocre (depuis le jaune-clair au jaune-foncé), terre verte, noir (charbon); souvent la peinture des vêtements est de couleur lilas qui d'après les analyses chimiques représente un colorant organique du type de pourpre ou de garance dont la chaux est colorée. Les traces de dorure témoignent que les boucles d'oreille, les coiffures, quelques autres objets (p.ex. l'éventail) étaient décorés d'or battu qui ne s'est presque pas conservé.

La couche picturale est couverte de suie, de morceaux d'argile appliqués, de traces de moisissure et de cristaux de sel. La moisissure représente des points noirs grans ou petits; sur certaines statuettes ces points forment des colonies surtout sur la préparation blanche. Comme suite de l'endommagement par des microorganismes la surface est gris-sale ("Tête de femme") ou couverte de taches noires ("Aphrodite et Eros", "Deux amies"). Comme l'analyse chimique nous l'a montré la noir de ces points parsemés se compose d'une partie organique et d'une impureté minérale, ce

qui caractérise les vieilles moisissures qui sont partiellement couvertes de sels cristallisés et qui pénètrent à partir du support d'argile sur la surface.

Ainsi le problème de restauration consistait à fixer la céramique, le support et la couche picturale, à réparer à toutes sortes de réparations grossières, à nettoyer la couche picturale de la crasse et de toutes les vieilles colles qui ont perdu de l'élasticité. Ce qui avait été compliqué dans ce problème de restauration, c'était le fait qu'il fallait consolider la céramique, le support et la couche picturale sans influencer sur la composition du support qui contient de la cire, qui se dissout dans presque tous les solvants organiques. Il était rationnel d'utiliser la méthode de restauration de l'encaustique sur une préparation poreuse et introduite à l'Ermitage en 1976. Suivant cette méthode on a consolidé le sarcophage peint de la ville de Kertch en calcaire, un ensemble de terre cuites peintes du tumulus Bolchaia Blisnitsa, un récipient en forme de figurine de la ville de Kertch.

Les épreuves préalables d'imprégnation et de consolidation superficielle des échantillons éprouvés (fragments de supports peints) avec une solution conformément de 10% et de 5% de polybutylméthacrylate à basse viscosité (PBMA-BV) dans le mélange des solvants: alcool éthylique, alcool isopropylique et xylol en proportion de 3:3:2 ont donné de bons résultats. Comme la crasse qui recouvrait la couche picturale était importante les objets étaient soumis à la première étape de nettoyage à sec et en utilisant un tampon imbibé. Les endroits friables de la couche picturale étaient parfois nettoyés avec la solution aqueuse de méthylcellulose à basse concentration (0.2%). Le procédé de nettoyage de l'encaustique avec la solution aqueuse de méthylcellulose était mis en pratique au laboratoire lors du traitement de la peinture du couvercle du sarcophage de la ville de Kertch. Après le nettoyage d'essai les endroits friables de la peinture sur la statuette "Femme assise au diptique" on a recouvert le cou, les épaules et la base de la solution de méthylcellulose. Après séchage ces endroits ont été nettoyés avec des tampons de coton humide (coton enroulé sur un petit baton taillé en pointe). Le nettoyage de vieilles colles dissolubles dans de l'eau s'effectuait suivant deux procédés: si l'état le permettait on enlevait les traînées de la colle avec un tampon humide. Ainsi on a nettoyé le visage de la "Femme assise au diptique". Dans la plupart des cas un tel nettoyage était impossible car la colle hydrosoluble a détaché la couche picturale et l'a enroulée. Alors on humidifiait un peu

ces endroits, tâchant de ne pas toucher à la peinture, on les redressait et les collait à leur place avec la solution de PBMA dans de l'acétone. Ensuite on dégageait la couche consolidée de la colle hydrosoluble suivant le premier procédé. La surface de tous les objets était imprégnée de la solution PBMA-BV de 5% dans le mélange indiqué de solvants. Pour imprégner on utilisait un pinceau; les objets comme règle étaient placés dans une chambre fermée et étaient exposés à l'action des vapeurs des solvants pour une répartition égale du polymère sur le matériau fixé, ensuite les objets étaient soumis au séchage à l'air libre. La quantité de couvertures atteignait le chiffre six: certains échantillons exigeaient la répétition du cycle d'imprégnation. On trempait les petits fragments des bases dans la solution de PBMA de 10% dans le mélange de solvants dans un bain pour 24 heures, ensuite on les séchait dans du papier couvert de colle sous une couche de sable. Les bases des statuettes très friables comme celles de "La femme debout à l'éventail" ont été consolidées suivant un procédé combiné: on saturait de solution avec un pinceau la surface supérieure de la base et après séchage la statuette était installée dans un bain avec de la solution à niveau de 2-3mm pour que la base puisse absorber la solution.

Au cours du nettoyage et de la consolidation des statuettes on a découvert des distorsions et des déformations dues à d'anciennes réparations. On a aussi découvert des particularités intéressantes de la peinture concernant la technologie de la production. Ainsi le diptique sur la statuette mentionnée plus haut avait été détaché et ensuite collé avec distorsion. Le battant pendant qui est un peu plus large devait se trouver sur les genoux de la femme, ce qu'on a découvert après avoir procédé au nettoyage et après avoir détaché le diptique. Il est évident que le maître a fixé avec de l'argile le diptique dans deux endroits avant la cuisson, car on peut voir des jointures de céramique épaissie sur les genoux de la femme de la statuette et sur le battant du diptique. Au revers du diptique et sur la statuette sous le diptique on a découvert qu'il n'y avait ni support ni couche picturale; il y avait seulement des touches de support et de couleur caractéristiques, dont le maître a légèrement effleuré le revers en paignant les côtés latéraux.

Tous ces faits nous renseignent sur la suite du procédé technologique: d'abord on procédait au moulage, ensuite on fixait tous les détails avec de l'argile, on séchait, on soumettait à la cuisson. Après la cuisson

on appliquait la couche de fond et on la peignait. Le diptique a été nettoyé des colles de restauration et a été joint à la statuette prenant sa position initiale. On a procédé de la même manière avec la statuette "Deux amies". Le bas piédestal profilé n'a pas été exactement collé, le bras gauche a été fixé avec distorsion dans deux endroits. Après avoir bien assemblé et bouché les craquelures de mastic on a pu découvrir le dessein plastique primitif. La colle utilisée était la solution de PBMA-BV de 12-15% dans de l'acétone.

Il est souvent impossible d'enlever la moisissure de la couche picturale des statuettes car la moisissure pénètre dans les couches profondes de la peinture, du support et même de la céramique. Le procédé mécanique de l'enlèvement des masses noires aurait provoqué des creux, ce qui est inadmissible. Dans de pareils cas on se bornait à la consolidation entière et parfois on clarifiait les taches noires avec un pigment ou un mastic. Le procédé mécanique de l'enlèvement des moisissures n'était utilisé que quand la moisissure n'avait pas pénétré dans la couche picturale et l'élimination de laquelle n'aurait pas changé la facture et le relief. Les cristaux de sel étaient aussi enlevés mécaniquement. L'étude et le traitement des échantillons de la collection de Tanagra seront poursuivis.

La restauration des statuettes de Tanagra était faite par les collaborateurs du laboratoire de peinture murale de l'Ermitage A.Blichner, T.Vassilenko, M.Vinokourova, L.Gaguene, E.Kalmikova, J.Natchinkina, G.Ter-Oganian, E.Cheinina.

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THE POLYCHROMY OF THE 13TH CENTURY STONE
SCULPTURES IN THE FACADE OF FERRARA CATHEDRAL

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ICOM Committee for Conservation
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Working Group: Polychromed Sculpture'

THE POLYCHROMY OF THE 13TH CENTURY STONE SCULPTURES IN
THE FACADE OF FERRARA CATHEDRAL

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SUMMARY

The 13th century stone sculptures in the porch of the Ferrara Cathedral showed a relatively well preserved polychromy under a thick layer of dirt and soot; the former was the object of the present study.

The original paint, mostly covered by repaintings, was found to be applied onto a lead white preparation which was in direct contact with the stone surface.

The pigments were easily identified but the analysis of the medium presented some difficulties because an 1843 treatment with linseed oil had completely impregnated the paint layers. Examination of samples by gas-chromatography could only show that oil and probably to a lesser extent protein also, were present in all the paint layers. However, from staining and solubility tests it was tentatively concluded that the medium of the original layers was probably oil while the protein could have resulted from the application of casein as a consolidant or, in some instances, from its use as the actual medium of some blue repaintings.

The painting technique is discussed, taking into account the antique written instructions for painting on stone and the results of recent scientific examinations of other polychrome stone sculptures.

INTRODUCTION

The main portal of the Cathedral of Ferrara and its porch are adorned by very important stone sculptural decorations.

The sculptures of the portal and the lower part of

the porch, dated 1135, are signed by Nicolò who is also the author of other important romanesque stone sculptures in north Italy such as those in the portals of the St. Zeno's church and the cathedral of Verona (1).

The loggia in the upper part of the porch was built a century later and its sculptural decorations representing the famous "Last Judgement" are probably dated 1240-1250. The author is unknown but iconographic and stylistic comparison with sculptures of the same period in the French cathedrals, particularly Reims cathedral and Notre Dame of Paris, suggested that he was probably French or an Italian who had worked in the French cathedrals (2, 3).

The scaffolding built for the preservation intervention on the porch, now in progress, allowed an inspection of the sculptures at close distance. It was possible to observe that under a thick layer of dirt and soot a great deal of polychromy is still preserved.

This note reports the results of the analytical study of the polychromy of the 13th century sculptures in the upper part of the porch. An analogous study of the 12th century sculptures is in program, to be carried out before starting the preservation work on this part of the porch.

PRELIMINARY INFORMATION

Before describing the present scientific investigation it may be interesting to note the nature of the sculpture stones and to remember the documentary information concerning the stone decay and the intervention carried out in the past on these sculptures.

The petrographic analysis showed that at least two types of stone were used for carving the 13th century sculptures: a micritic limestone and a sandy chert (4).

Without entering into detail of the alteration mechanisms of these stones, it can be said that the decay is certainly a process started a long time ago. In fact the deterioration of the sculptures of the Ferrara porch is clearly claimed in 1907 (5). On the other hand the documents concerning the conservation works carried out on the façade in the first half of 19th century (6) complain of the bad state of preservation (particularly of the upper areas), allude to substitutions of the "broken" parts (also in the porch), and describe a final general treatment of the stones with linseed oil.

Earlier interventions on the sculptures are not clearly documented but it may be noted from documentary sources that the earthquake of 1570 badly damaged the

the porch and that the polychrome brick statue of the Virgin (put in the centrum of the loggia in 1427) was regilded in 1590 and 1676 (7). It is possible that the repaintings which emerge from the present analytical study, could have been carried out on these occasions.

Other interventions on the sculptures (after those of the 19th century), on the contrary, are well documented (6). They were carried out in the early 20th century (between 1901 and 1907) and later on, in 1932-33. The documents concerning these interventions do not allude to any general preservative treatment of the sculptures, but it is possible that a consolidant treatment with casein, which seems to emerge from the present analyses, could have been carried out on these occasions.

METHODS OF ANALYSIS

Samples were taken from the frieze with angels in the tympanum (namely from the ground behind the angels and the upper blue-gilded frame) (Fig. 1), from the robe of Christ, and from the ground of the frieze with leaves above the "Last Judgement" (Fig. 2).

Cross sections of the samples were prepared and observed under the microscope for the determination of the layer structure. The pigments were identified by microchemical analyses (8). Identification of media was carried out by solubility tests and by staining tests with acid fuchsin and with amido black 10 B for protein and with Sudan black B for oil (9, 10).

Examination of some samples was also carried out by gas chromatography. The samples examined for the presence of oil were saponified, the isolated fatty acids methylated with diazomethane and the resulting esters chromatographed (11). Some samples were examined also for the presence of protein by looking at the amino acid composition. After acid hydrolysis and treatment with ion-exchange resin to remove inorganic material, the amino acids were derivatized by first methylating using dry Methanol-HCl and then trifluoroacetylating using trifluoroacetic anhydride.

RESULTS

The results obtained showed that the sculptures had been repeatedly repainted and underwent preservation treatments which impregnated all the paint layers with different substances. A comparison of the results obtained with different methods of analysis and a careful speculation allows one to distinguish



Fig. 1 - The porch of the Ferrara cathedral, detail of the frieze with angel and the upper frame.



Fig. 2 - The porch of the Ferrara cathedral, detail of the "Last Judgement" and the upper frieze with leaves.

the original polychromy from the later additions.

The medium

Gas chromatographic analyses were first carried out on samples which mostly consisted of the whole range of paint layers down to the stone. The results showed that all the samples contained large amounts of drying oil, the low palmitate/stearate ratio of which indicated that it was linseed oil. It was suspected that this came from the unfortunate treatment of 1843 when the sculptures were impregnated with linseed oil. A further examination of one area, the ground of the frieze with Angels (Fig. 3e), was therefore undertaken, samples having been taken at four different levels through the paint corresponding approximately to the four layers shown in Fig. 3e. Each layer, however, showed exactly the same fatty acid pattern and had almost identical palmitate/stearate ratios, namely 1.23, 1.16, 1.15, and 1.13. One must reluctantly conclude that the 1843 treatment completely impregnated the paint layers and that it is therefore impossible to obtain direct evidence for original oil paint.

Some of the foregoing samples were also examined by gas chromatography for the presence of protein. Two samples, that from the red robe of God (Fig. 3a but the pure red pigment layer only) and from the frame above the frieze with angels (Figs. 3c and 3d, most layers) showed significant amounts of protein with an amino acid pattern which came closest to that of casein.

Therefore oil, and probably to a lesser extent protein also, were present in all the paint layers which meant that at first we could not be sure whether the medium of the original paint was oil or casein from milk. However staining tests suggested that the protein was present in greater concentration at the surface where it could have resulted from the application of casein as a consolidant (may be in the early 20th century) or, in some instances, from its use as the actual medium of some blue repaintings. From solubility tests on the original layers their medium is tentatively concluded to be probably oil.

This conclusion seems to be in agreement with antique written painting instructions. In fact:

- Old treatises and recipes describe a glue for wood make from cheese and lime (12,13,14,15) but do not allude to casein tempera for pigments. The only exception is the suggestion, given in 16th century recipes, to use milk as a medium for blue pigment in frescos, with the specified purpose of retaining the

the colour (16, 17).

- Casein tempera appears to be a relatively modern paint medium. However it was also largely suggested by the restorers of the last century for consolidating mural paintings (18). It is possible that a consolidant treatment with casein could have been carried out in the early 20th century (see above).
- On the other hand specific instruction for painting on stone are not frequent in the old literature. A review of the authors writing from 12th to early 15th century (the period that can interest in the present case) shows that Petrus de S. Audemar (19) and Alcherius (20) describe how to paint "round figures" but they do not clearly say if wood or stone sculptures are concerned and, in any case, they do not mention the paint medium. Only Eraclius (21) and Cennino (22) clearly describe how to paint on stone and both of them quote oil as paint medium.

The pigments

The pigments identified in the original layers are not many: lead white, azurite, malachite, vermilion and red lead. They seem to be used rather pure, scarcely mixed with white or with black. An exception to the use of unmixed pigments is the red colour which is sometimes obtained from a layer of pure vermilion but, more frequently, from a mixture of vermilion and red lead.

The gilding decorations were made by application of gold leaf over what appears to be a thin oil-resin layer (containing no pigment) directly applied over the local colour layer. This gilding technique appears much simpler than that described by Cennino who suggests a complex multilayer preparation for the stone to be gilded (23). It appears also simpler than the stone gilding methods described by later authors who always suggest mordants prepared by mixing different pigments with oil (24, 25, 26) or with oil and varnish (27).

The layer structure

Staining tests carried out on several samples showed the presence of a relatively greater quantity of protein not only at the surface of the paint layers (due to casein tempera repainting and consolidation, as above discussed), but also in the upper portion of the stone. Therefore it may be that the stone surface did undergo a pre-treatment with glue before it was

painted. A treatment of this type, probably intended to decrease the absorption of the paint, is suggested by Cennino when describing stone gilding (23).

After this possible glue treatment the stone surface received a general preparation made by a layer of rather stiff lead white. The lead white layer appears in the cross-sections much more cracked and fragmented than the paint layers above. This may be explained by alteration due to penetration of water, much easily absorbed and evaporated through the relatively porous paint layers than through the stiff white lead. In a way the preparation layer acted as a water-proofing film which, when applied on stone, just decays by cracking and forming exfoliating fragments.

Over the preparation layer, the paint was applied in a single layer which probably covered all the local field. This means that the decorations were obtained by superimposing over the ground colour the gold leaf (as already described) or a layer of a different colour.

The last is probably the case of the robe of Christ. The sample from this area came from the lower border, where a red colour appeared under a general greenish surface layer. The sample cross-section showed a green layer of malachite under a red layer containing vermilion and red lead (Fig.3a). Both these layers are probably original: the robe of Christ could be green with red decorations and was later overpainted all green.

The samples analyzed showed several repainting layers, but probably not all of the overpaints covering the sculptures, because we tried to take the samples in the relatively clean areas where the dirt and some probable overpaint layers have disappeared.

All the repaint layers analyzed seem to have oil media with the exception of the blue repaint of the frame above the frieze with Angels. This frame was originally painted blue with a layer of azurite and decorated with gold leaf. It was regilded at least two times and repainted with ultramarine blue in a medium containing casein (Fig. 3b,c,d). The use of the precious ultramarine (lapislazuli) may indicate an antique date for this repaint, probably made using milk as a medium, as suggested in 16th century (see above). It may be interesting to note that the regildings observed in this area were made by applying the gold leaf over mordants containing pigments, according to the instructions given in general since 15th century onward.

The repaints observed in other areas frequently

Fig. 3 - Photomicrographs of paint cross-sections, photographed by reflected light.
 Magnification on the printed page: 0.1 mm .
 The layers are described in the following captions from the bottom layer upward.

a) Sample from the robe of Christ

1: Stone - 2: Malachite + some black - 3: Red lead + vermillion.

b) Sample from a blue area of the frame above the frieze with angels

1: Stone - 2: Lead white preparation - 3: Azurite
 4: Ultramarine, repainting - 5: Superficial dirt.

c) Sample from a gilded area of the frame above the frieze with angels

1: Stone - 2: Lead white preparation - 3: Azurite
 4: Brown oil-varnish film, preparation for original gilding - 5: Gold leaf - 6: Ultramarine, repainting.

This cross-section was photographed after staining with acid fuchsin which stained red the ultramarine repaint layer, probably containing casein medium.

d) Sample from same area as c)

1: Stone - 2: Lead white preparation - 3: Azurite
 4: Brown oil-varnish film, preparation for original gilding (gold leaf no longer present) -
 5: Preparation for regilding - 6: Gold leaf -
 7: Preparation for second regilding - 8: Gold leaf - 9: Trace of ultramarine repaint.

e) Sample from the ground of the frieze with angels

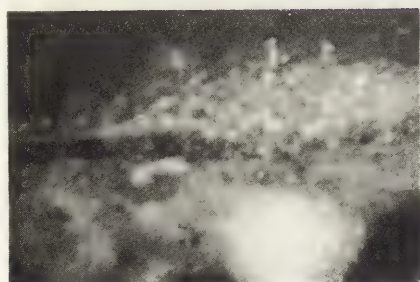
1: Trace of lead white preparation - 2: Malachite
 3: Red lead + some lead white, repainting -
 4) Vermilion, repainting.

f) Sample from the ground of the frieze with leaves

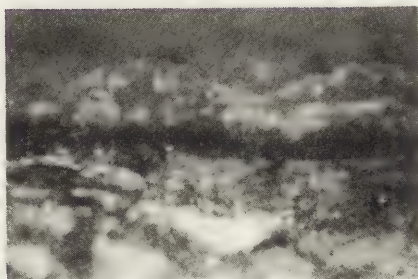
1: Stone - 2: Lead white preparation - 3: Red lead + vermillion - 4: Azurite - 5: Malachite.
 Layers 4 and 5 appear to be repaintings.

g) Sample from same ground as f)

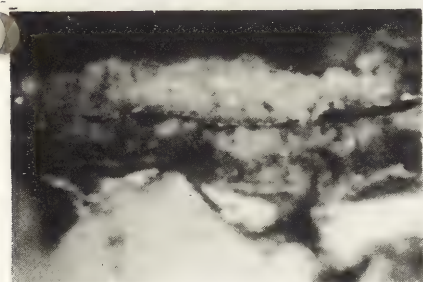
1: Stone - 2: Lead white preparation - 3: Vermilion - 4: Malachite, repainting - 5: Superficial dirt.



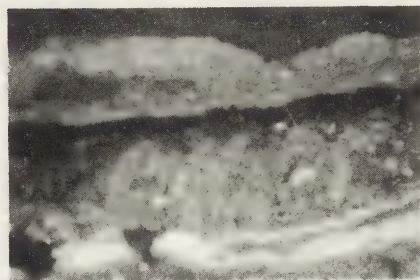
a)



b)



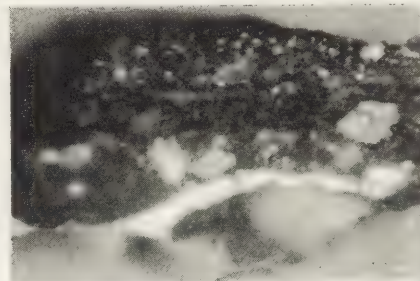
c)



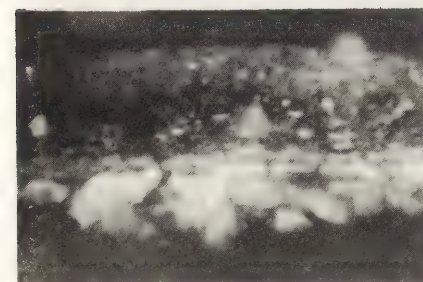
d)



e)



f)



g)

Fig.3 - Full caption on facing page.

showed change of colour with respect to the original one:

- The ground of the frieze with Angels, originally painted green with a layer of malachite, was repainted red (Fig. 3e). It may be interesting to note that the red colour was obtained in this case by a layer of vermilion over a layer of red lead, while in the original red areas vermilion and red lead were mixed in a single layer.
- The ground of the frieze with leaves, originally red in colour (obtained by a layer containing vermilion and red lead), was repainted blue with azurite, then green with malachite (Fig. 3f). While there is no doubt that the green layer corresponds to a repaint because it is divided from the paint layer underneath by some brown dirt, this is not the case for the blue layer, which appears well adherent to the original red layer underneath. However a close inspection with magnifying glasses, in situ, suggested an homogeneous original red colour for this ground area and no blue decorations over red.

This conclusion is in agreement with what observed in a sample taken from another point of the same ground which shows the original red layer only covered by the malachite layer (Fig. 3g); this green layer, which certainly corresponds to a repaint (as above seen), appears in this cross-section in close contact with the original red layer underneath, exactly as the blue repaint above considered.

DISCUSSION

The present scientific examination can give an idea, also if not complete, of the brilliant original polychromy of this sculptural porch.

It was repainted many times, probably in old time. An early date for the repaintings is suggested by the fact that the taste for polychrome stone sculpture was certainly lost in Italy at least by the late Renaissance time. This hypothesis seems to be confirmed by the analysis of the repaint layers which suggests antique paint technique.

Considering the original paint technique some comparison can be made with the results of scientific examination of other polychrome stone sculptures. The notes on this subject are not many but we can consider three of them, all rather recent.

While the paint technique of Dutch polychrome stone sculptures of the late 15th century (28) appears rela-

tively more sophisticated in comparison with that observed here, a more useful comparison may be carried out with the paint technique of sculptures in Venice (29) and in France (30), carved about in the same period as the sculptures here investigated.

The polychromy of the 13th century sculptures in the central portal of St. Marco church in Venice was studied by Lazzarini (29). The paint technique of these sculptures, still influenced by the byzantine tradition, shows some differences with that observed in the Ferrara porch. In fact in Venice a gilding technique with gold leaf applied over a brown preparation containing burnt ochre was observed; it is a technique that Lazzarini, on the basis of technical examination of byzantine polychrome statues, suggests as typical of byzantine painters. Beside this it does not appear that a general preparation (for instance the lead white preparation seen in Ferrara) was applied on the stone surface of the St. Marco sculptures. Moreover to obtain blue-gilded decoration, azurite was applied over the gilded ground, with a layer order which is just the reverse of that observed in Ferrara.

The paint technique observed in the Ferrara porch shows much closer similarity with the one recently studied in the sculptures of the cathedral of Strasbourg (30). These French sculptures, of about the same age as the ones we are interested in, showed a general lead white preparation covering the stone surface, a single layer of oil paint above it and a brilliant polychromy obtained with just the same pigments which were used in Ferrara.

It may be interesting to note that the instruction to paint stone given in the third book of "Eraclius MS.", which according to Mary Merrifield was probably written by a Frenchman in the 12th or 13th century (31), just suggests painting with colours mixed with oil over a very stiff, finely ground white preparation, laied over the stone surface.

Considering that the sculptor working in the upper part of the porch of the Ferrara cathedral is now supposed to be French, or an Italian who knew the French workshops well, the above technical considerations may probably be interesting also for the art historians.

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81/5/4

POLYCHROMY ON 13TH AND 14TH CENTURY
SCULPTURES

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Working Group: Polychromed Sculpture

POLYCHROMY ON 13TH AND 14TH CENTURY SCULPTURES

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The theme "Polychromy on 13th and 14th Century Sculptures" is intended as a contribution on the technology and restoration of sculptures.

I should like to treat this subject by discussing a few works of art renewed in the last years by restoration workers at the Institute of Monument Conservation in the GDR, also in cooperation with free-lance specialists, indicating some technological features concerning the material and colouring.

They are selected examples for such works of the fine arts that are originally related to the building, such as choir barriers and monumental triumphal crosses.

It is necessary to establish a connection between the sculpture and building in a special manner, so as to particularly emphasize the character of evidence and the information value of the work of art in situ within the interior.

Halberstadt, St. Mary's Church, Choir Barriers,
Halberstadt Cathedral (Fig. 1)

About 1200 A.D., the choir barriers of St. Mary's at Halberstadt were covered with plastic ornaments. The idea of the decoration is the same as in St. Michael's at Hildesheim. The brick wall is covered from without by a high relief and crowned with a wooden column gallery. About the original western side of the barrier there is no expertise nor any information available. The vaulting of the intersection was made only after the barriers had been stuccoed, as the pattern of the vaulting arches intersects with the barriers at all four ends.

The barriers consist of hewn limestone blocks on which the plaster has been applied in several layers. A low

oblique profile in stone and an ornament at the eastern corner of the southern barrier allow to suppose that there had been a more ancient state of the choir-barrier. The wooden arches on the barrier essentially belong to the time it was made with a few columns replaced in the 19th century.

The grey-whitish plaster of Paris that has become very hard was applied in layers on a lower layer of stucco that was about 1 cm thick. Into the white, soft and slowly setting stucco the sculptor has moulded the form, cutting in edges and folds with sculptor's instruments.

Already during the setting of the massive forms as a result of drying out -as the cavities behind the stucco layer lead to suppose- part of the mass has gone off from the wall.

Crevices through older parts of the foundation and mechanical damage during the secular use of the building, after taking off the coating caused by the war, made it necessary to fasten the stucco with dowels.

The Halberstadt choir barriers belong to the few medieval stucco sculptures on which the colouring was preserved to a large extent. On each side of the barrier, under round vaulted arcades there are sitting six apostles with Christ or Mary in the centre. The present colour expression conveys the original intensive tints only with extreme limitations, as several colours, as the blue background, and the white stains on various garments can only be traced in minute remnants. We also come across these blues in book and wall paintings of that period, as well as on the triumphal cross to be mentioned later of the Cathedral. Apart from that, a green marginal strip like here at the choir barriers also occurs on the Cathedral cross.

For the coloured design of the background there is also an example of complete gilding like on painting on wood. It was found on the tympanum of the "Golden Gate" in the Freiberg Cathedral. It was traced there and analyzed by us.

The sequence of colours in Halberstadt varies as at the Groeningen gallery between red and green coats and garments enriched in a few figures with blue and white parts. Christ and Mary are made conspicuous by their purple coats as central figures. Furthermore, the gilding covered the aureoles and arcade vaults. On the columns, a red, green, and golden rhythm can be traced.

In the case of some well preserved pinks with Mary and Jacob Caebadaeus, the colour photographs convey the very subtle hues and the fine drawing lines. Above Mary's head, in a dark green strip there are the gilded letters with the apostles' names painted in white. In Mary's pink during the uncovering or analyses from 1959 to 1964, all

layers covered with paint were left over for later times.

The pink of Jacobus Zaebedaeus has been well preserved in the right half of the face as it was protected by a column of the former tabernacle. Below the light blue colour of the hair applied during the second colouring there is a grey hue.

After removing the dirty layer and fastening loose colour particles, the colouring operations could be established both by stereomicroscopic separation of pigment layers and by microchemical colour analysis. In this respect, the zone of overlapping colour layers has an important role to play.

To make clear the patterns existing on every layer of paint in garments and coats, work sheets were made on which by juxtaposing various single cuts, colour sequences were painted over figures, the background, and pillars.

The various layers of painting were uncovered only in small probes to preserve the paint. The overall surface of a certain painting period can only be reconstructed from these findings.

The coats and garments of the apostles at the northern side show the change of reds and greens with white undergarments, whereas on the figures of the western half of the southern side only red coats and blue or green garments are visible, and on the eastern half, only green coats and red garments. In general, undergarments are coloured white on the figures of each side. The trimmings of the coats and garments are rimmed by a broad golden strip.

The variation of red and green on the ornamental ribbons also covers the leaves contrasting with a dark red background. The spandrel of the stucco surfaces between the arcade vaults and the ornamental ribbon are only painted with winged angels. They were done only on the northern side. On the southern side there are leaf motives painted over the chinks.

The drawings of all patterns on the five colour layers of Matthew's coat indicated for the first layer a plant ornament in dark red between yellow stars. The pattern appears as if embroydered, suggesting a comparison with real textiles, the centaur dalmatic in the Halberstaedt Cathedral treasure.

Tendrils embroidered in golden thread on red silk are only partially visible. But they oscillate across the whole surface as freely as on Matthew's coat.

Layers two and three were covered with rosettes. Patterns on layer 4 are lacking. On the fifth layer, textile forms were painted again.

The loss of the blue colour is explained by binding agents containing glue. All other pigments are bound with oily ingredients.

In Halberstadt Cathedral, there is a triumphal cross group consisting of five figures above the wood screen on a supporting beam. John, Mary under the cross and the six-winged cherubs form an optical unity with the architecture of the wood screen. The supporting beam is occupied by busts of the apostles and prophets.

The origin of the group is brought into connection with the consecration of the newly vaulted romanesque cathedral about 1220 A.D. The figures have been displaced from the preceding structure -the third on this spot- into the new building of the 13th century. In so doing, the apostles' group was shortened and the distances of the cherubs to the central group were changed. During the repair work on the figures from 1950 to 1956 the preserved colour vestiges on the group were analyzed.

On all parts, under two layers covered up with paint, major partial sections of the more ancient version could be uncovered. With only the colour of wood being extant on major portions, it determines the present-day colour picture of the group essentially with the exception of the pinks.

The found remnants of the colouring allow to reconstruct the original colours. Conspicuous is the rich use of gold on a white priming colour, as well as on the cherubs' wings and on the coats of the assistant figures, as well as in the form of trimmings on the garments.

Here it is bordered with narrow red strokes, pervading the garments in vertical and horizontal lines. The wheels below the cherubs and the balls in their hands were covered with gold. Also gilded were the loin cloth and aureole of Christ, as well as the garments of the figures at the end of the cross. Minor gold remnants were found on the canopies and the horizontal profiles at the apostles' beam, with the cloaks of the apostles, prophets and angels having large gilded surfaces under the layer of paint.

Another hue, blue (lapis lazuli on black) was used for colouring Mary's and John's garments and as a background in the trefoils on the cross and in the arches at the apostles' beam. The brownish-rose coloured pinks show characteristic dark red point on the cheeks. The large eyes with black pupils in light brown eyeballs are shaped by dark brown lid and brow drawings prolonged especially with Mary at the upper lid lines. On the cross, two angels are holding the moss green *lignum vitae*. It is bordered by a profile made from a plate and a bar.

On it were painted oval shaped precious stone imitations

alternating in red and green with minor circles arranged in groups of two. The bars at the vertical beam that are chequered in black and at the horizontal beam with a tile pattern are lying on darkened silver plating lined with gold varnish.

The colouring consisting mainly of gold and blue is enriched to a minor extent by the red interior sides of the cloaks and garments, as well as by purple red shoes and wheel fillings. Brown and grey colours of the hair and the bluish hues of the fabulous animals are recognized only at looking more closely.

The gilded loin cloths may also be found in a number of monumental Saxon triumphal crosses.

About twenty years after the Halberstadt triumphal cross was made, in these monumental groups varying uses of gilding can be observed. On the figures of the Freiberg and Wechselburg group gilding as surface finishing only occurs on garments under red and blue cloaks.

Naumburg

Another example of polychrome stone sculptures is to be presented by the result of analyzing the donor figures in the western choir and on the relief of the western rood-loft.

Naumburg Cathedral has been erected in 1210 in the place of a previous church building.

The western choir and western rood-loft were built about 1250. The western choir contains the well-known twelve donor figures in stone that are standing in life-size on a gallery in front of the vault structure and the arcades in the square choir, partially directly connected to the masonry.

The choir is completed by the rood-loft.

This is carrying under the parapet reliefs with scenes from Christ's passion and has in its centre a passage with the entirely plastically formed figures of a triumphal cross group. Perhaps it is a unique experience for visitors to be allowed to enter directly below Christ's arms. The plastic programme forms a unity with the stained-glass windows.

The representation of the donors that lived 200 years before this choir was built instead of saints in a sacral room included into a picture programme uniting the redemption and the Lord is ascribed to a master.

He has been named the "Naumburg Master" in the history of art.

The opinion of those art historians who time and again refer to several hands and to the master and journeymen problem is to interest us in this context only as an indication to focus our own capability of observation. But if

we look at the figures more closely - and we have studied them in several stages of the work both in their stone making and their colouring - then we find two painting periods. On the rood-loft reliefs there are still remnants of a third coat of paint.

The first painting that is overlaid for viewers at the donor figures and on the western rood-loft by the second painting in part was applied *b e f o r e* the transfer of figures and reliefs.

A corner was beaten off from Dietmar's hat after it was painted to transfer to the point a superposed squared stone. Here this operation is to be controlled.

The canopies under which the relief scenes are inserted on the rood-loft can also be used as further evidence for the colour treatment before the erection.

As can be seen by means of a mirror, they were also laced everywhere at the inner sides, which would not have been possible any longer after the transfer. When parts of the rood-loft were removed for reasons of conservation, it was possible to have a look at otherwise covered spots beyond grasping that are not visible in front and are covered with paint all the same.

In spite of remarks in the literature about the colour on the donor figures we could ascertain that they were completely painted.

This also applies to such spots that cannot be seen by the viewer standing in the choir. E.g., the ribbon on Reglindis's cloak was also gilded on the inner side and provided with a red toothed pattern. Another example occurs on the pommel of Dietmar's sword hilt. Gilding and colour are spread over the entire pommel.

The subtle treatment of detail reflects on a small scale the attitude on the basis of which these works of art were made, as well as the fact that on a large scale in the formal design of the sculptures the terrestrial viewer is completely ignored.

On the western rood-loft the upper canopy zone, the foliage arranged under the scenes and the columns that separate the scenes vertically were painted and partially gilded. In the lower rood-loft zones and on the gable outside the quatre-foil, no colour remnants could be traced so far that you may call as the original material.

Characteristic colours for the first painting:

Christ's and St. Peter's gilded cloaks

Pilate with a sumptuous, purple red toga, lined with hermine, circular, golden pattern and a broad ribbon at his breast on which extant black remnants give a clue to pseudo-Kufic.

The remaining figures have red, green, and brown garments without any trimming.

Remarkable is furthermore the characteristic pink modeling. In the transition zones to the hair and beards fine hair strokes are going off from the pink and brows and lid lines in black and red are painted with a thin brush.

To the coloured picture of the first version there be long then blue-green and dark brown hairs. Judas always has red brown hair as a distinctive feature.

The extremely precise pictorial patterns, e.g. on the table cloth of the Lord's Supper and on the hair net of the maidservant that are clearly visible only on the rear part of the head - the hair net being formed of golden threads layed out rhombically and of red and green filling strokes - these and the patterns of various belts may be compared to contemporary textiles, and the same applies to fur imitations at the inner side of Pilate's cloak and on the cap, as they show the transformation of real furs into pictorial forms of expression.

The relief figures are standing out against blue backgrounds, whose colour is still extant in remainders and vestiges in stone. When taking the grey, Baroque paint cover, in various spots remains of blue (lapis lazuli) were found on the stones and in filled joints in the background. There is also revealed from that that the blue paint was applied prior to erection and originally retouched after the joints were filled.

The rich colourful first painting comprises 24 hues with the second painting revealing only 18 hues. They are limited in principle to the figures in a colour similarly to the first painting. A few cloaks, as e.g. with Judas are bright and dark striped. The second painting can be dated by the patterns to about 1500 A.D.

As to the colouring of the crucification group, a pattern on the white cloak of Mary is evidence for the fact that this gilded quatrefoil rimmed with blue and designed in regular proportion represents a motive not used so far at Naumburg. In size as here with Mary, gilded panes of glass on St. John's cloak are rather related to the patterns at the end of the century, e.g. in the three Magi group in Würzburg Cathedral. As a result of this, as is revealed by the history of building, the crucification group would belong to the last figures of the master.

To sum up the first colouring we can say as opposed to the second, that the colour with its calligraphic patterns is even more closely related to the iconographic meaning than the side quoted time and again at Naumburg of turning to the naturalist elements.

Rossow

An important work of wood-carving from the first half of the 14th century is the altar top from the little church at Rossow. The three part altar top was repaired by us from 1961 to 1964. In so doing, two pieces of parchment were found on which the lords of Lindow are mentioned in an otherwise illegible text.

In the 17th century, the altar came to Rossow and was put up there without its wings due to its size (2 metres in height with an open span of 6.4 metres). The middle part was given decorating Baroque ornaments at the sides and two Gothic elliptical arches as a crowning. The two wings were put away, and at the time of processing, they were lying in the tower as boards on which the bell boys stood. This procedure has caused the almost complete loss of the colouring at the inside of the wings.

After restoration the winged altar, central part and the inserted wings could again be put up in the village church, in its western part, however.

The pictures and figures are arranged in two zones. In the central part above there is Mary's coronation in the midst of apostles, below is the crucifixion with Mary and John, as well as the prophets Jeremiah and Isaiah in the upper corners of the scene, also surrounded by apostles.

On the festive side of the wings, this programme is continued in painting. Only a few remains are extant of this, supposedly martyrs like St. Lawrence were represented. During the restoration, the figures were cleaned, and in some places, layers covered up with paint were removed.

The figures are wearing gilded cloaks and garments whose lapels are contrasting with bright red, blue, green, and dark red. On Christ's and Mary's garments molten glass beads that are flat and round and pearl-sized are evidence to the fact that the trimming was originally studded with imitation precious stones. They were inserted in the gilded surfaces of seems and belts.

On the garments and cloaks of the apostles, painted white lilies alternate with green quadrifoliums and red rosettes with fleur-de-lis. There are added cruciform and circular, as well as square-sectioned ribbons at the trimmings and thin seam stitches emphasizing the difference of the apostles' figures contrasting with the more sumptuous version of the Christ and Mary group.

All hair and beards and architectural parts are gilded. The bright pinks have red eye drawings and reddish transitions to the hair, so that soft and tender hues are set out against golden parts.

In the gilding, the varying technique of polished and de-lustred areas attracts attention because of differing hues. Moreover, on major surfaces of the shrine background there occurs a black-brownish gilding. Therefore, differences

may be distinguished in the front views of figures and architectural parts as opposed to the backgrounds, with the exception of the area behind the crucification group. This is an early use of gold alloys. Gold alloyed with copper oxidizes with time. In the gilding of the apostle figures, besides, the highly polished and dull polished gilded area was applied on white or red brown gold size.

On the scrolls are inscribed the names of the apostles and the continuous credo, the text of the Apostles' creed, is marked in black letters. The carved and painted representations were surrounded by frames carrying on a silvered background rhombical and circular glass panes framed in gilded tin. The stained glass panes are also present on the Gothic gables and the arches of the architecture. Owing to this, by including gold and glass, a gorgeous frame was made reminding of the hey-day of metal reliquaries.

As some parts of the tracery and architectural elements were lacking, endangering the support of the remaining parts, they had to be reconstructed on the grounds of statics. Thanks to the existing leaf beadings, the Gothic gables in the upper zone could be completed by analogy to the wings. These complements were entirely rimmed and gilded.

On Christ's body an opportunity presented itself for removing the second coat of paint already considerably damaged. We have covered a spot in the lateral wound surrounded in the second layer of painting by a large cluster of blood drops and that in the original version had only been painted as a vertical path with a little starlike wreath of drops - we have covered it by retouching, not removing that paint - so that this blood track is recognized in side light, but that it does not become visible when viewed directly.

All complements had been ensured by plaster-casts and nails in the oak wood so that an entire completion of the tin pattern can be conceived. From the viewpoint of performing few complements it proved during the restoration work that not only the mentioned plastic parts, but also the frame (being rare) could be plated of the tin patterns and completed with stained glass.

As on the altar wings owing to insignificant colour remnants the wooden surfaces had to remain visible to a great extent, only the tin patterns without stained glass were used on the frame. Hence, the frames of the wings have been adjusted to the colour reduced on the surfaces.

Erfurt

A very interesting work, both for the type of the Virgin statue and for the polychromy of the wooden sculpture in the 14th century stands in the Anger Museum at Erfurt.

Mary, less than lifesize with the child is standing on the moon that is in full round shape. Behind her is a rear wall on which a pedestal and a canopy are fastened. The oblique surfaces on both parts indicated that two opening doors were fastened to either side.

Of this type of a single figure in a shrine there are unfortunately only a few examples left today. Often not only are the wings lacking that are standing separately in a museum as is the case, e.g. with St. Olaf's shrine at Stralsund, but so are the canopy and the pedestal.

The Erfurt statue is also called "Mary with the stags" because of the jumping stags represented on her cloak. The sculpture is made of linden-wood and may have been made between 1365 and 1370. The original version is rather dirty, but well preserved. The rear side is also original with gilded rays and an aureole, and so are the canopy and pedestal.

This version is composed in the following manner: After the white garment was made as a surface, the shapes of the stags were painted with red albumen or glue and covered with dull polished gilding. Contours and inside drawings in black create the pictorial shape. Between the stags, there is a pine-cone pattern outlined in black alternating with red or green bark. The organic red has faded and so have the hues on the extant shadowy shoots between the stags and the pine-cones.

A richly appavelled textile concept must originally have been the basis of this version. The white coat has a gold trimming 2 to 3 centimetres broad that is accompanied by two red strokes. On this trimming, a Gothic plant ornament was stamped with little punches.



Fig. 1 Halberstadt, Chapel of the Holy Virgin, 14th century. Stone sculpture with original polychromy

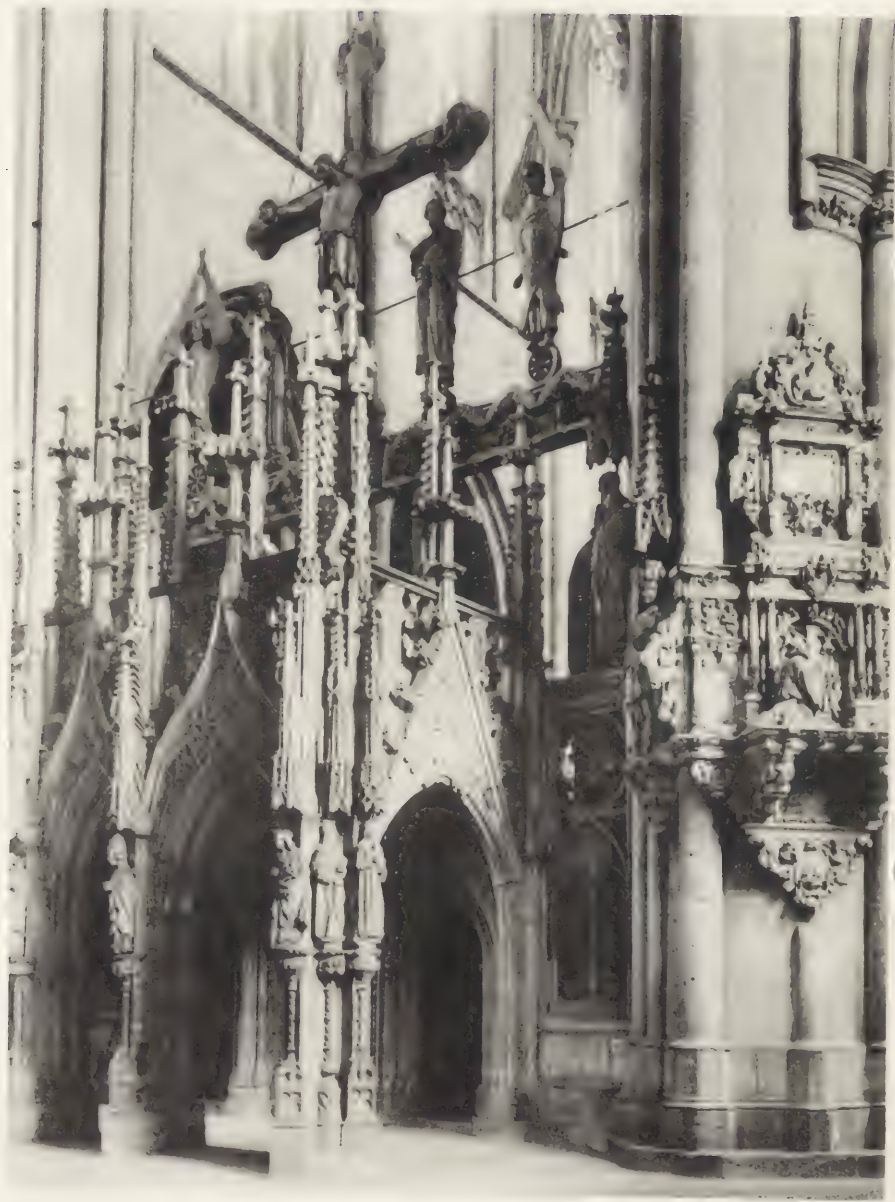


Fig. 2. Halberstadt Cathedral. Triumphal Cross Group, c. 1210, after restoration.



Fig. 3. Halberstadt, St. Mary's Church. South choir barriers, c. 1200.
After restoration.



Fig. 4. Halberstadt, St. Mary's Church. South Choir barriers, c. 1200
During uncovering of the original paint layer in the strip above
St. Mary's head.



Fig. 5. Naumburg Cathedral. Lectern (westside), c. 1260.
Reliefs: Pilate washing his hands and two soldiers.
After restoration, original paint layer partially uncovered.



Fig. 6. Naumburg Cathedral. Lectern (westside). Detail from the relief with the two soldiers. Structure on the surface of the cloak as an imitation of a woollen fabric with original paintlayer.



Fig. 7. Naumburg Cathedral. Portal with Triumphal Cross Group with the relief of the Passion, c. 1260.

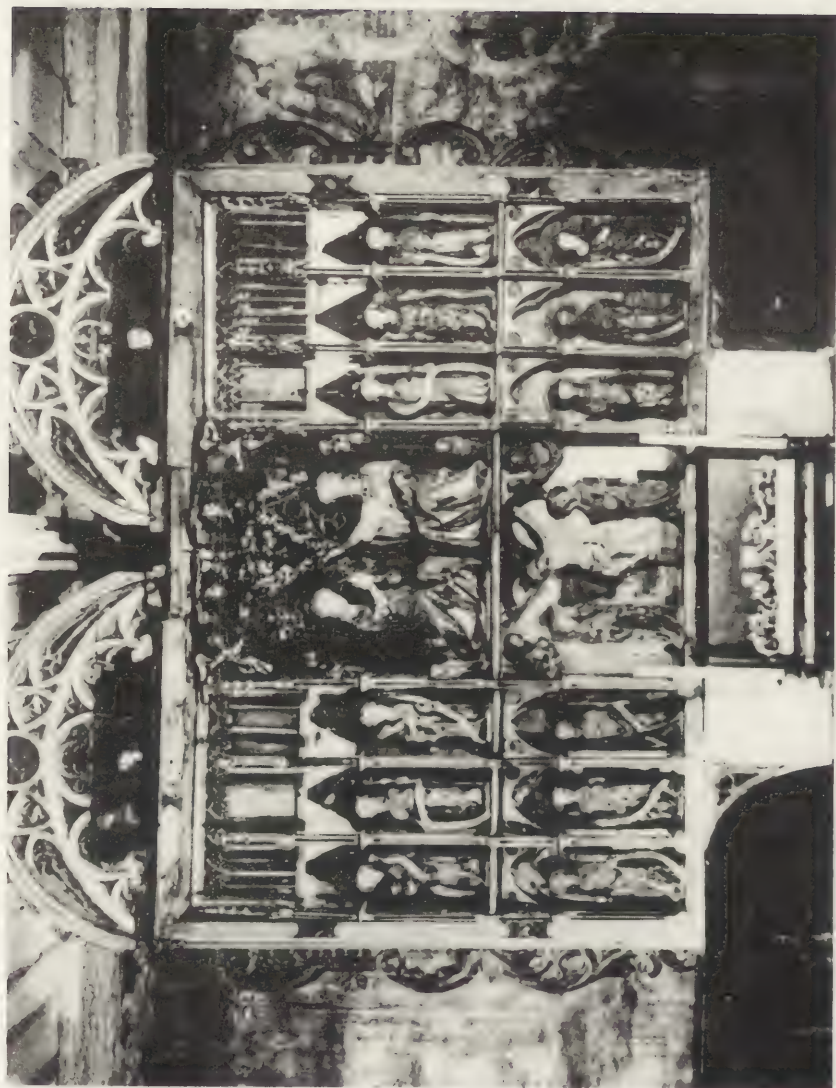


Fig. 8. Rossow, Church. Winged altar, c. 1330. Before restoration.

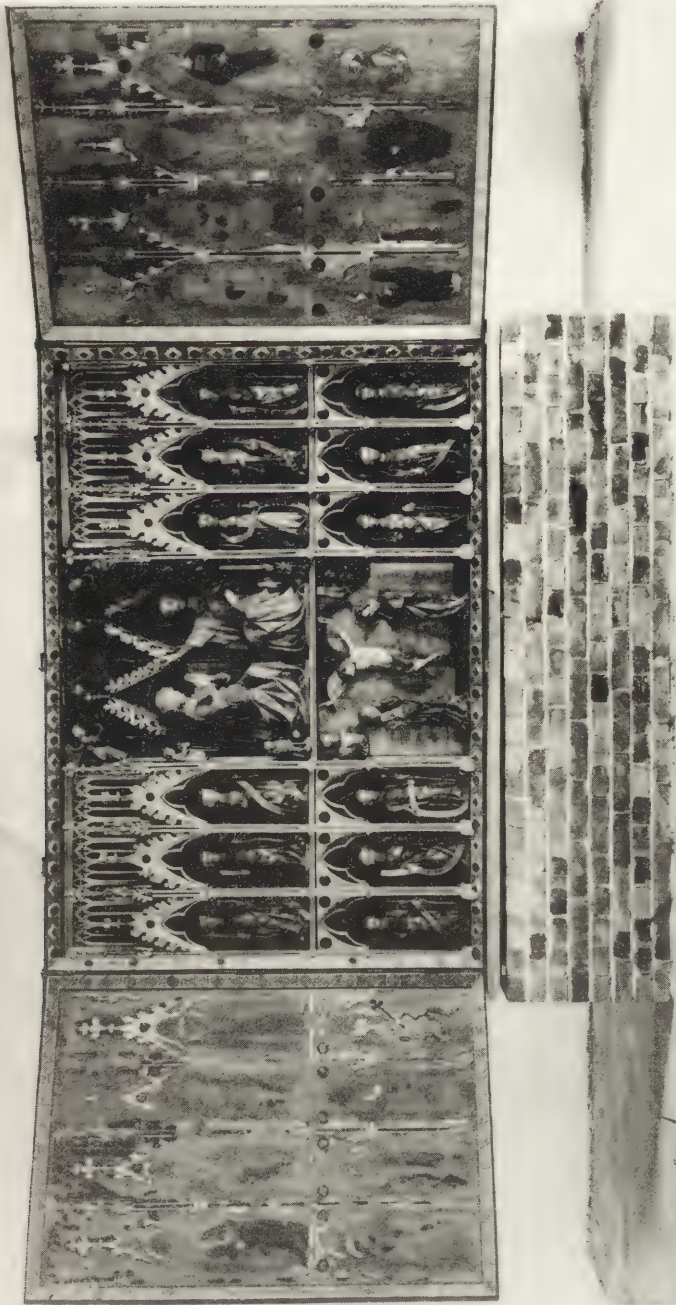
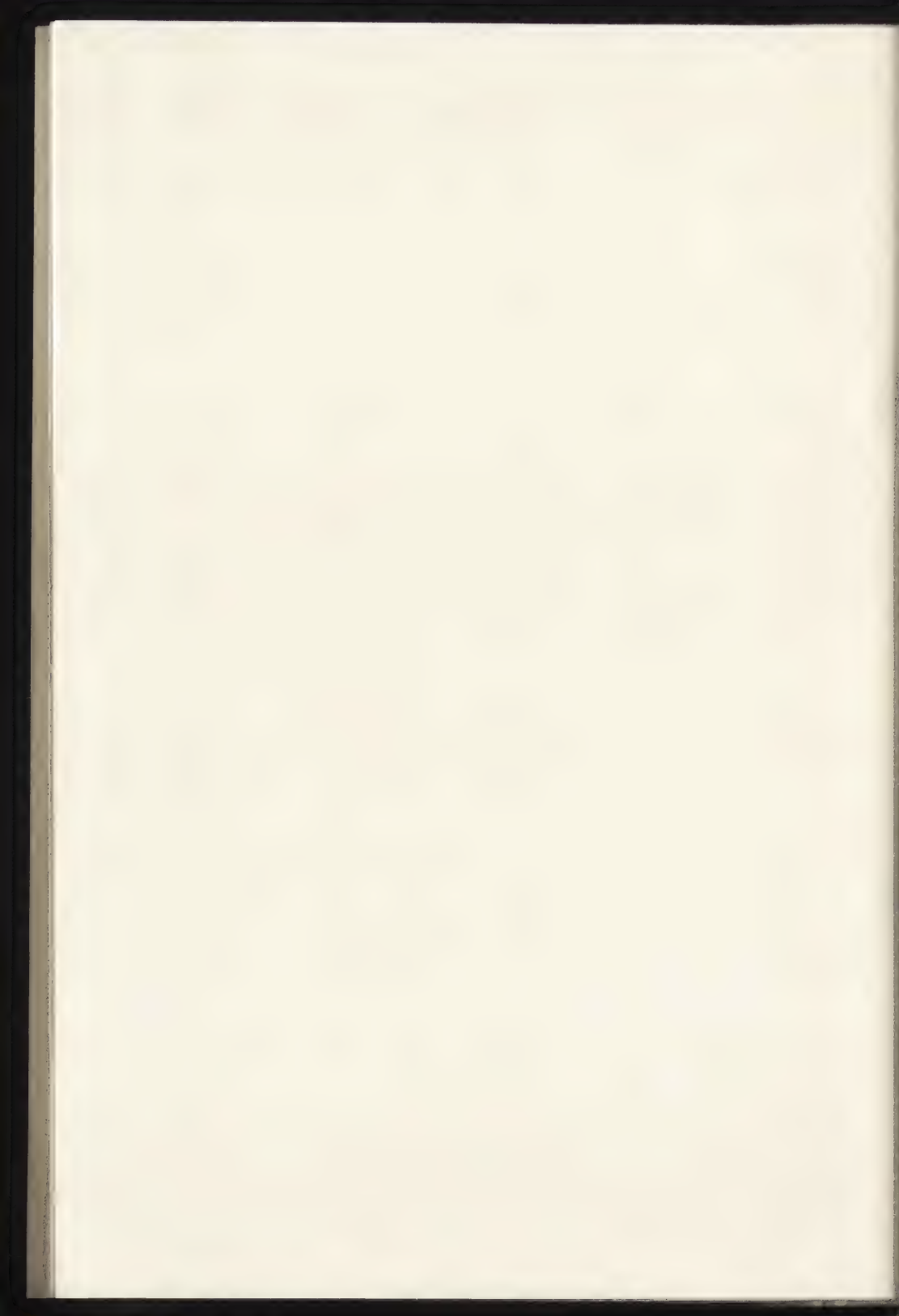
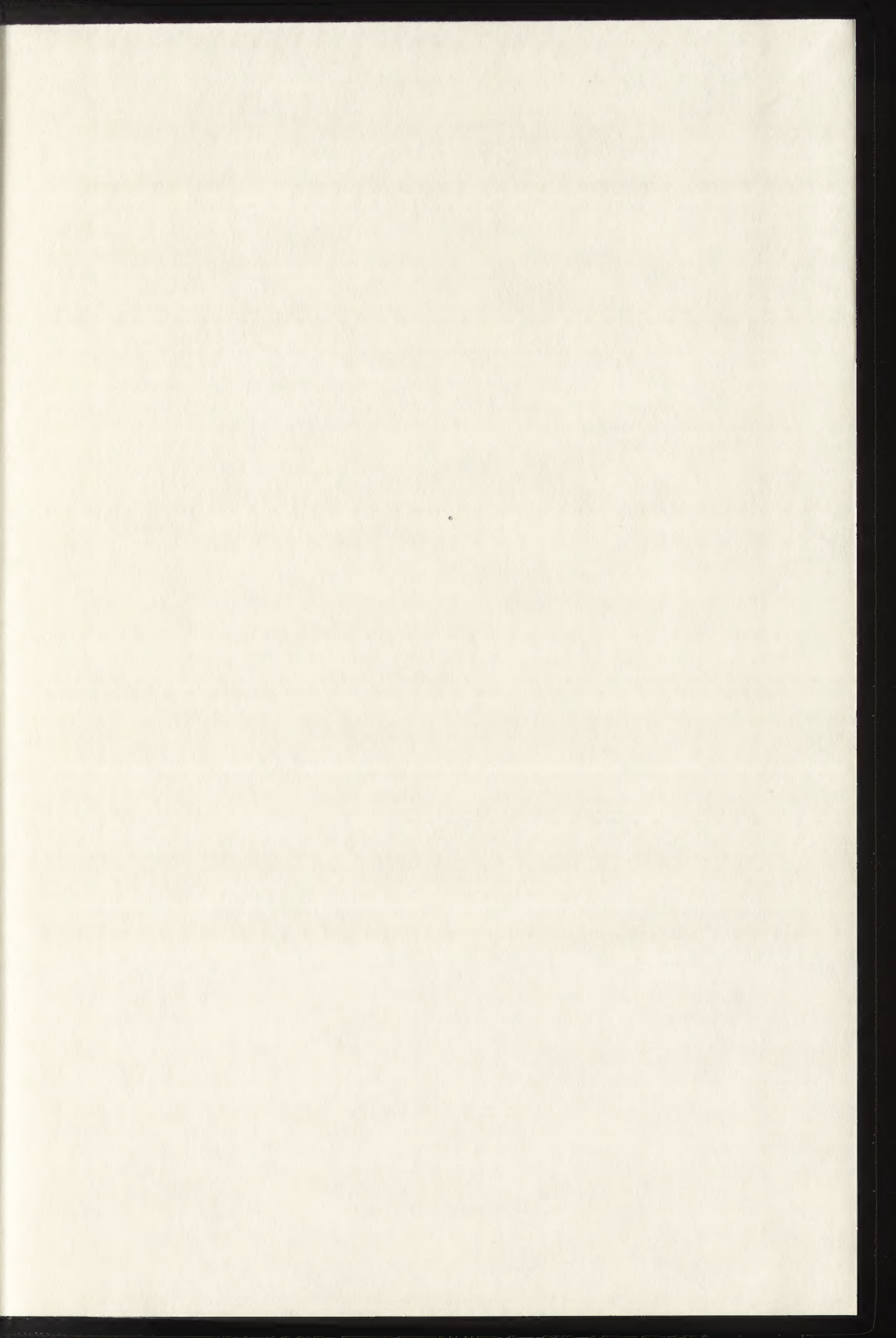


Fig. 9. Rossow, Church. Winged altar. After restoration with the wings rejoined.

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